ENGINEERING AND
BOILER HOUSE REVIEW
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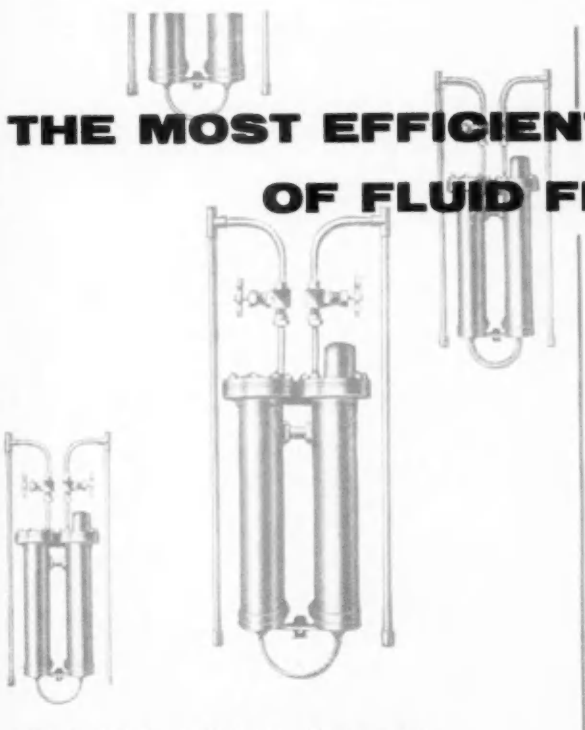
VOL. 75 NO. 3 • THE PIONEER STEAM JOURNAL • MARCH, 1960

Electroflo
Meters & Controls

THE MOST EFFICIENT MEANS OF FLUID FLOW MEASUREMENT



'Miniature' instruments for graphic consoles and comprehensive supervisory panels.

1 One operating principle — one general construction mode — for all fluids and gases under all conditions of measurement. Minimum service requirement.

2 Standardised, independent and interchangeable reading instruments — located at any distance from actual measuring point: separated grouped or duplicated to meet any operating or supervisory requirement.

3 Linear scales. Square root extraction effected by parabolic contour of resistance element.

4 Full 4" mercury rise.

5 Unrestricted mercury column gives maximum sensitivity to flow rate changes. Accurate to within ±0.5%. Differential pressure change modifies circuit resistance.
Conductance proportional to flow rate: easily checked in situ by substitution of standard resistance.

6 A.C. mains operation: unaffected by supply voltage and frequency variations.

7 NO CASTINGS. — Interchangeable tubular manometer with drop-forged ends. Readily available for any specified line pressure. No glands: integral equalising valve: over-range protection and dirt traps

8 High-speed, frictionless integration. Integration is totalising conductance meter measuring amperes x time/volts.

9 Wide choice of interpretive instruments — see illustrations.

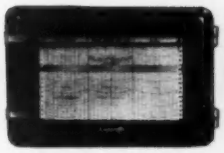
10 Equipped for data reduction: control circuits and available for long distance transmission. Also accepts 3-15 p.s.i. pneumatic signal. Further particulars on application.

Model No. 365
6"x 6" rate of flow indicator

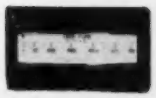
Model No. 259
6"x 6" high-speed integrator

Model No. 199
4", 1000-hour strip chart recorder

Model No. 355 12" diam. rate-of-flow indicator


Model No. 350 multi-point, 12" continuous roll chart recorder

Model No. 224
12" diam. recorder: 10½" diameter linear chart


Model No. 223 10" scale edgewise type rate-of-flow indicator

TENS OF THOUSANDS IN OPERATION IN EVERY CLASS OF INDUSTRY THROUGHOUT THE WORLD. FOR FURTHER PARTICULARS, ASK PUBLICATIONS DEPARTMENT FOR CATALOGUE No. 65

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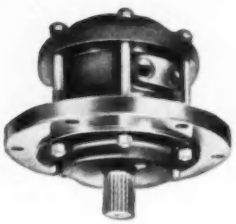
THESE double-acting units give semi-rotary motion up to 300° for single vane and up to 120° for double vane units with torques ranging from 1,270 to 1,100,000 lb/ins. at 1,000 p.s.i. Autoloc mechanical locking can be incorporated and shafts may project at either or both ends. Units can be arranged for foot or flange mounting. Normal maximum operating speed is 2 radians per second.

They have wide application in any field in which oscillatory angular motion is required and are particularly appropriate for the operation of plug valves, vanes, doors, stirring or agitating equipment, sand slingers, etc.

This is just one group of a wide range of Lockheed hydraulic units of which full details will be sent on request. Lockheed engineers are always ready to advise upon the use of units, devise schemes of hydraulic operation and control and install complete hydraulic systems.



This flange-mounted semi-rotary slave lends itself to many uses, including operating stirrers for liquid and semi-liquid products, and actuating plug or butterfly valves, where the unit can be flange-mounted directly on the valve body: many other such applications are easily arranged.

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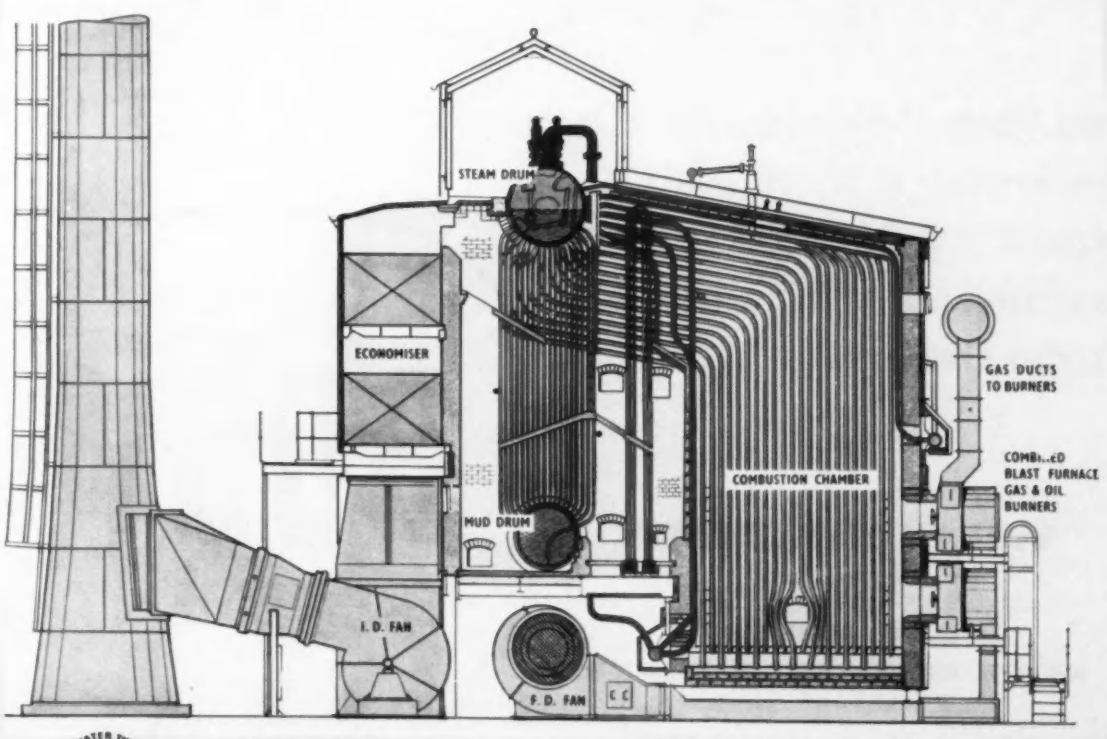
Below is shown the arrangement of a John Thompson 'Two-Drum' boiler fired by blast furnace gas or oil at Messrs. Stewarts and Lloyds, Bilston. Above: one of the boilers is seen during erection.



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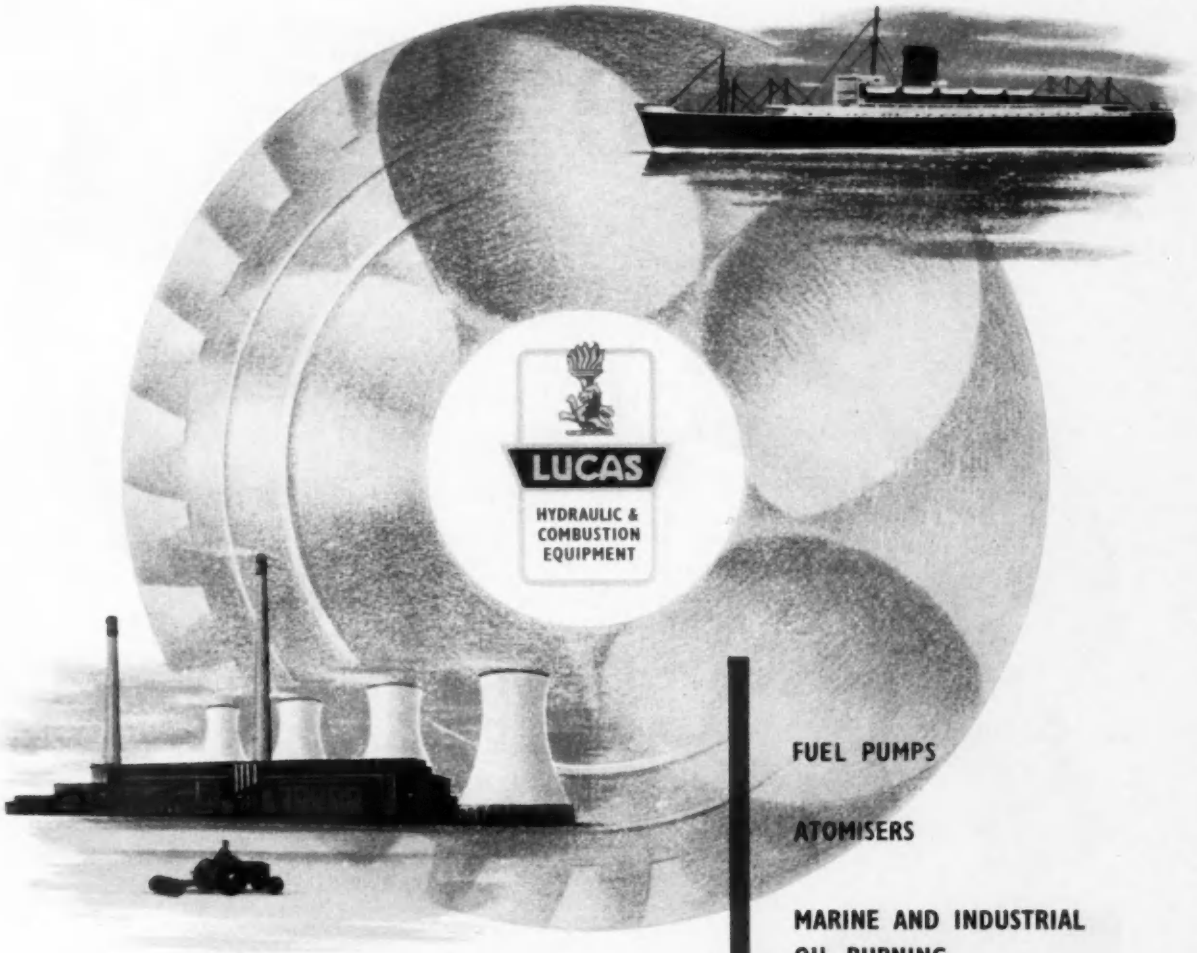

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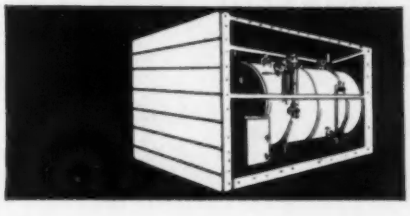

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Close-up of slag adherance chipped away, showing DOHMseal treated bricks beneath. Without the application of DOHMseal the boilers need to be rebricked every six months.

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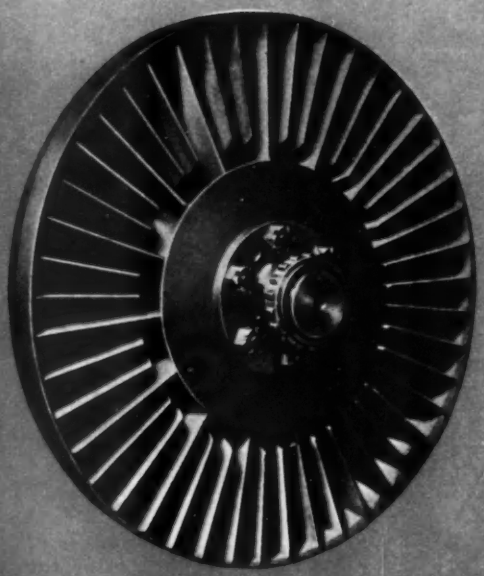

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- 10% to 15% saving in power effected by infinitely variable speed regulation.
- At 'blow off' condition reduced pump speed considerably lowers discharge pressure.
- Maintenance costs substantially reduced.
- Simplest electrical equipment and maximum reliability.

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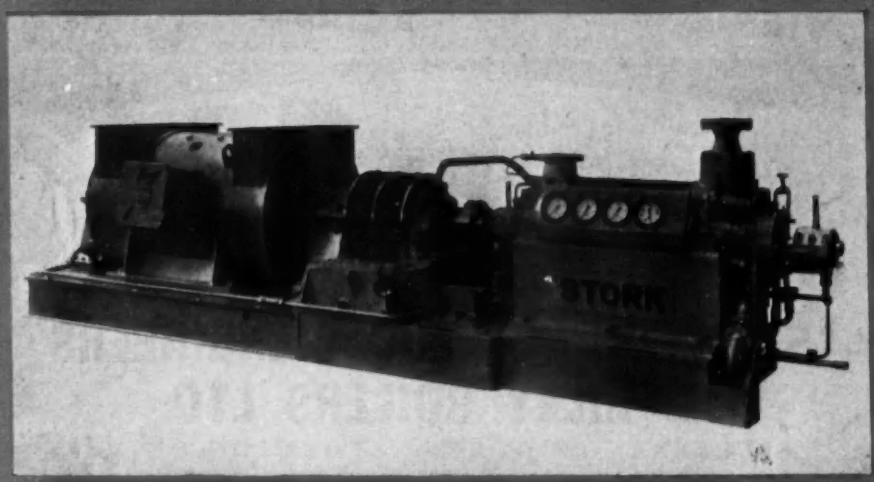

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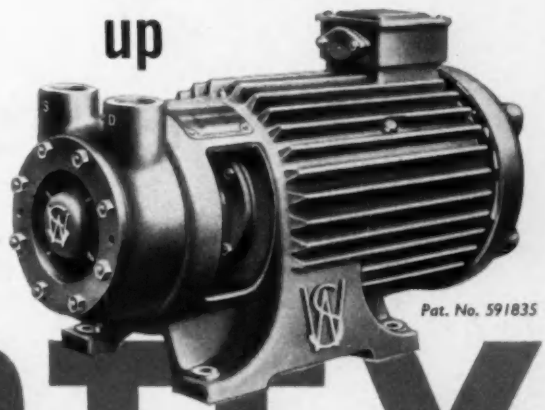

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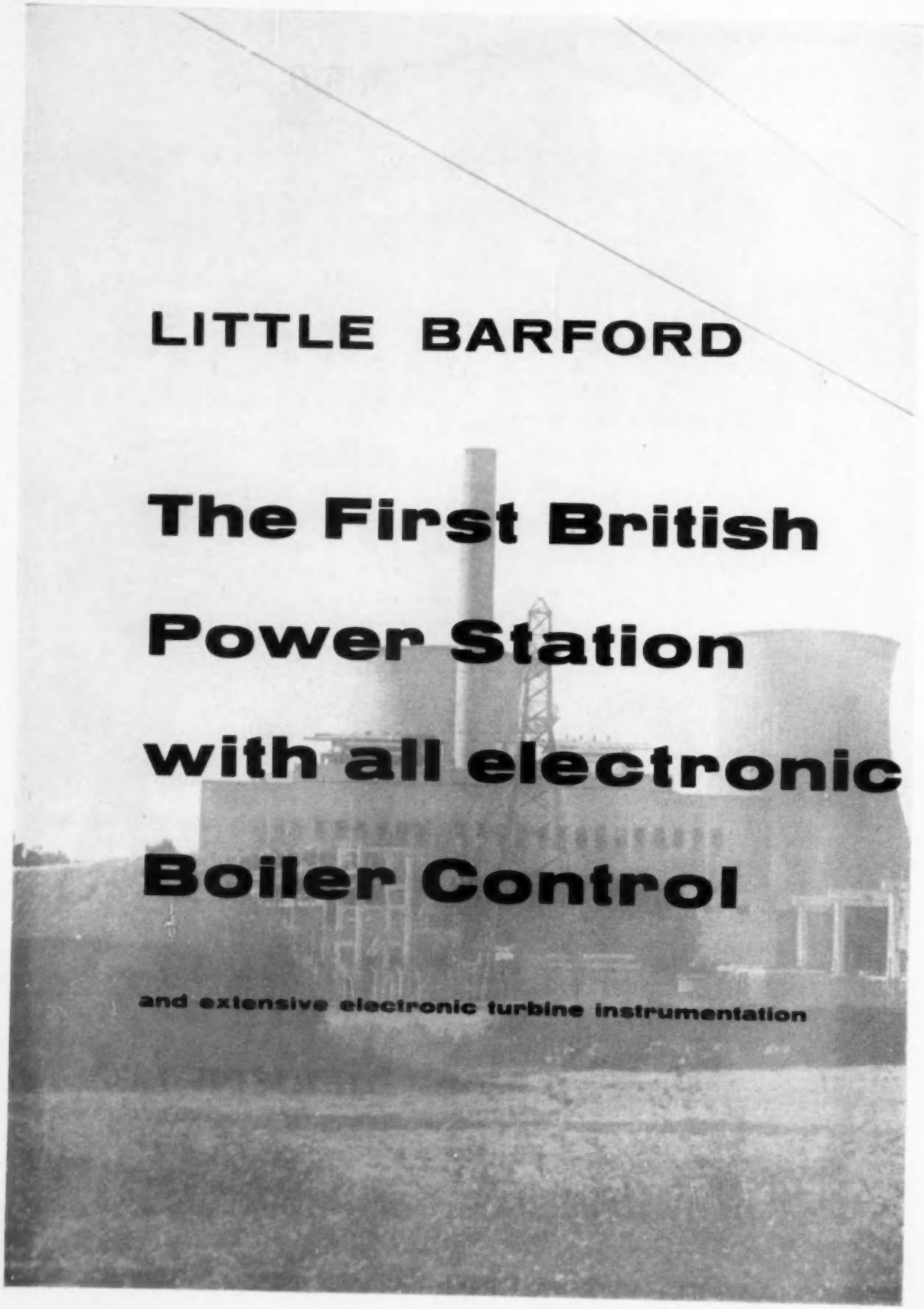
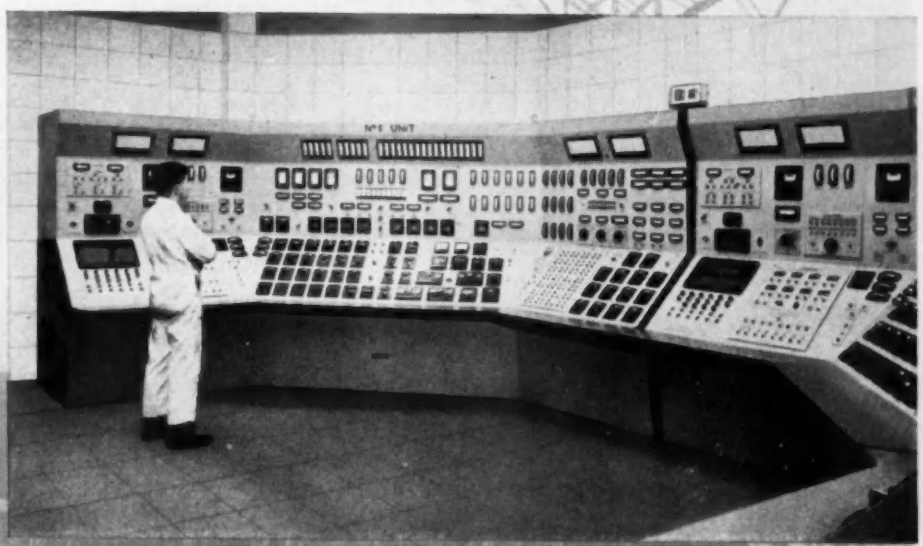


The first power station in the world to be controlled electronically was in Newfoundland using Evershed equipment. Other Evershed installations followed rapidly at Calgary, Wabamun, Vancouver, and now the first in this country—Little Barford. This major contribution to industry includes the provision of electronic transmitters, process controllers, analogue computers and electro-hydraulic positioners, indicators and recorders, plus the know-how of experienced engineers backed by a large and world famous organisation.



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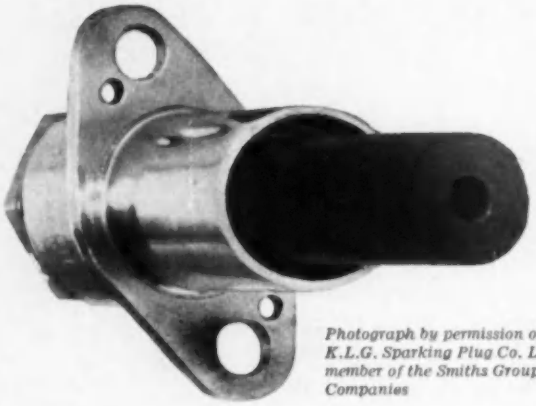


Photograph by permission of the K.L.G. Sparking Plug Co. Ltd, a member of the Smiths Group of Companies

REFRAX refractory

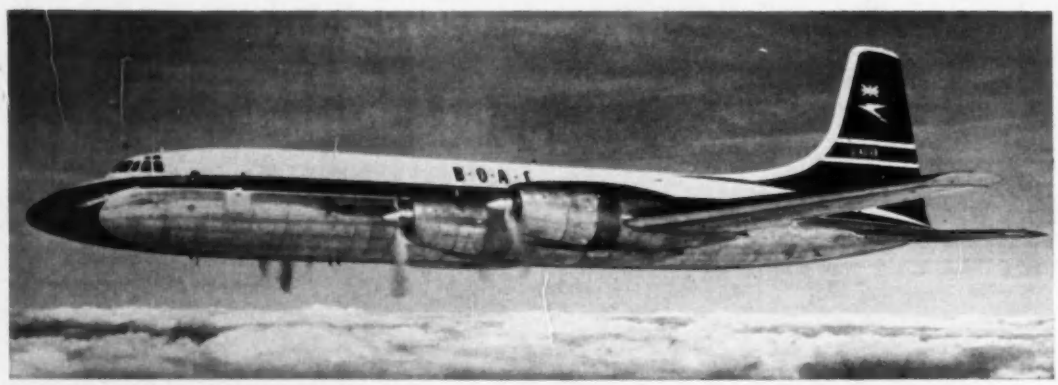
Regd

for the jet age

For economy, jet and turbo-prop planes fly high, where temperatures may be 40° below zero. An interruption in the continuous process of combustion can result in a "flame-out", presenting the problem of re-lighting the fire in the sub-zero hurricane that blows through the combustion chambers. Various devices have been invented to counteract "flame-out", but the simplest is the "Glow Plug"—a device developed in collaboration with Smiths and Bristol Siddeley Engines Ltd—which re-ignites the fuel in even the most rigorous conditions.

The re-ignition problem was solved initially by the use of platinum alloy, but REFRAX refractory material has replaced this, not only at a fraction of the cost but also giving several times the life.

The manufacture of refractory material to fine-dimension limits—as specified by the aircraft industry—at reasonable cost and in large quantities is exceedingly difficult. But CARBORUNDUM have achieved just this, with their REFRAX Nitride-bonded Silicon Carbide.



Photograph by courtesy of Bristol Aircraft Limited

Products by CARBORUNDUM TRADE MARK can cut your costs

We are indeed proud that Bristol Siddeley Engines Ltd have accepted REFRAX refractory as standard material for the "Glow Plug" safety device in the Proteus engine, powering the Bristol Britannia airliner. We should be pleased to solve your own particular refractory problem.

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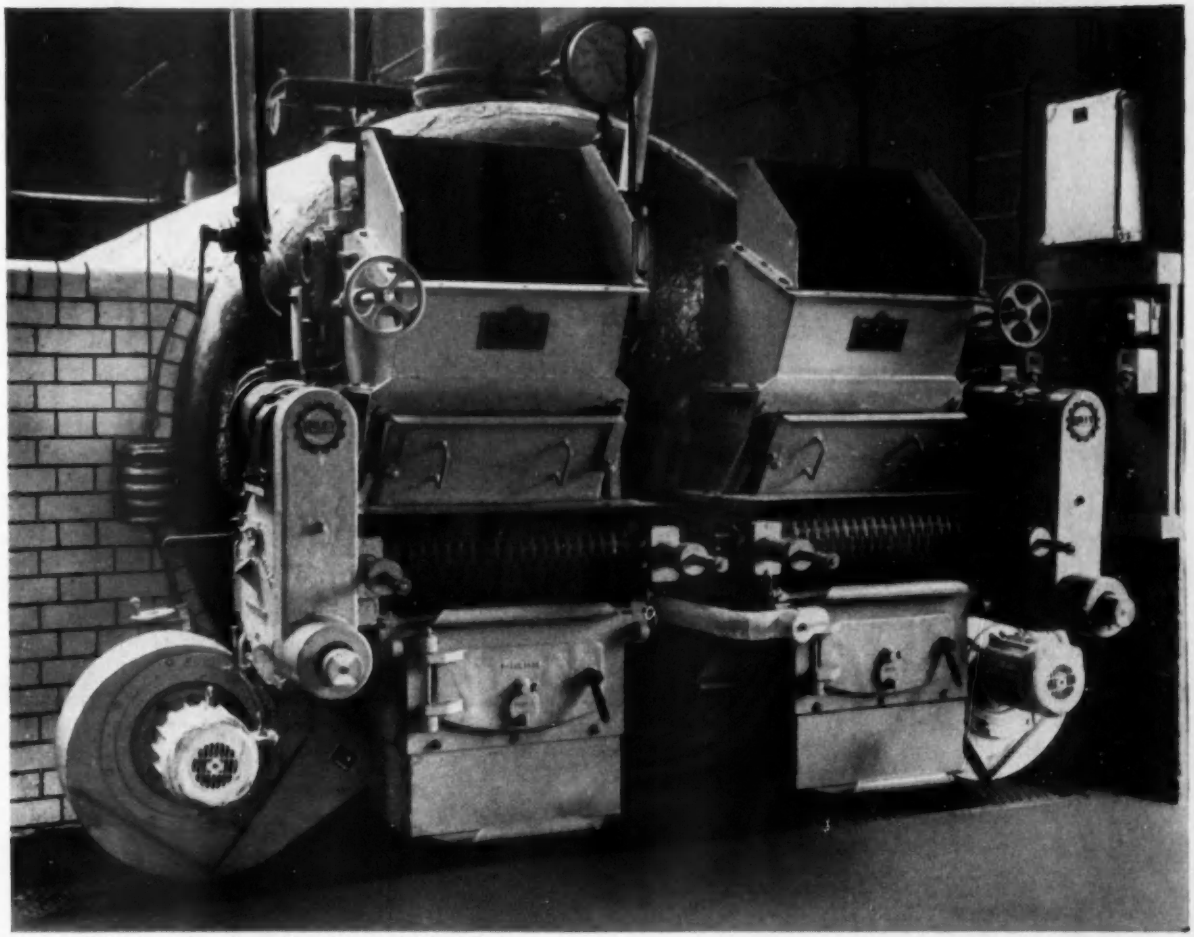
Burn low grade coals with high efficiency

on RILEY TYPE 'T' CHAIN GRATE STOKERS



Two type 'T' stokers firing a Lancashire boiler at a Midland Works

The Riley Type 'T' stoker was developed specially for Horizontal Shell boilers to burn the cheaper industrial slack coals which are usually high in ash content and unsuitable for other types of stokers. Combustion is clean, efficient and smokeless and full boiler output can be maintained at lower costs.

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Efficient burning of small bituminous coals is a feature of all Riley Stokers. The range includes, in addition to the type 'T' stoker, underfeed designs for every type of boiler. All provide smokeless combustion and are exempt from the provisions of the Clean Air Act.

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Photograph by courtesy of Davey, Paxman & Co. Ltd.

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The photograph shows the insulation of five Davey, Paxman Ultranomic boilers at the Bristol Aeroplane Co. Ltd.

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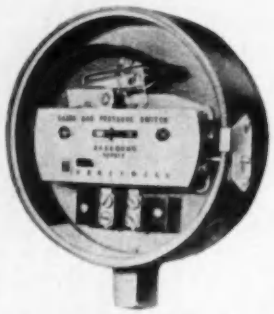

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C437A for low pressure cutout
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These new pressure switches are specially designed for industrial use . . . specially made to withstand heavy duty in corrosive atmospheres . . . specially valuable as a simple means to precise automatic control of hazardous and non-hazardous gases. They can be used as safety cut-off switches, pressure controllers, differential pressure controllers and in liquid level applications. To every application they bring enduring Honeywell qualities— completely safe operation, robust construction, clear view of mercury switch and scales, ease of installation and maintenance.

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pressures 5 to 100 psi
C447A for low pressure cutout
C447B for high pressure cutout
C647A for SPDT switching

Also available for pressures 2-20" water, C645A and C645B, low pressure two-position switches incorporate the seal-off diaphragm. C645B can be supplied with automatic lock-out.

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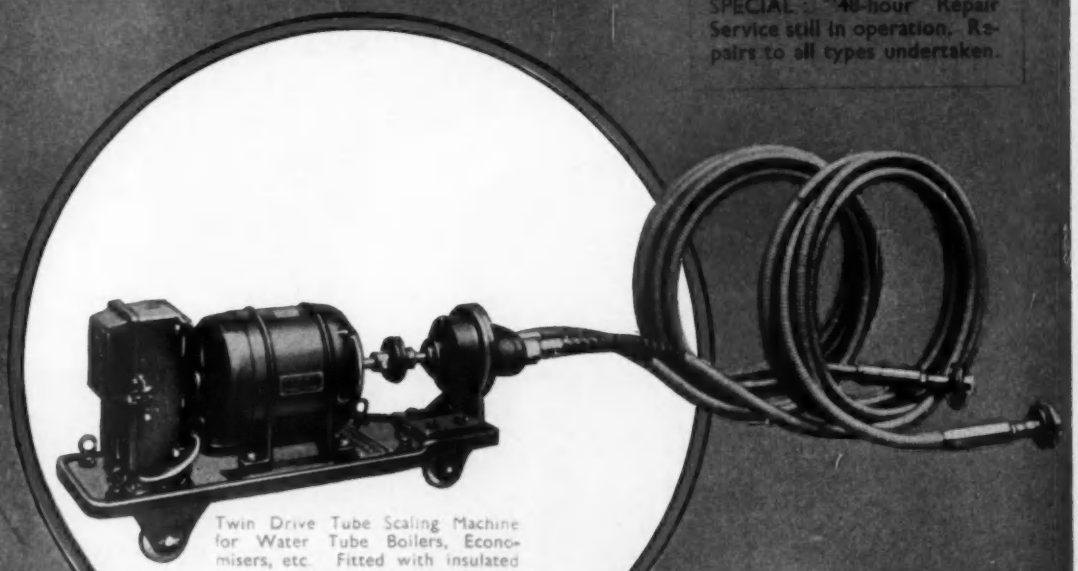

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Illustration by courtesy of S. SMITH & SONS (ENGLAND) LTD. shows work carried out by F. A. NORRIS & CO. LTD. at the Boiler House of their factory at Witney.
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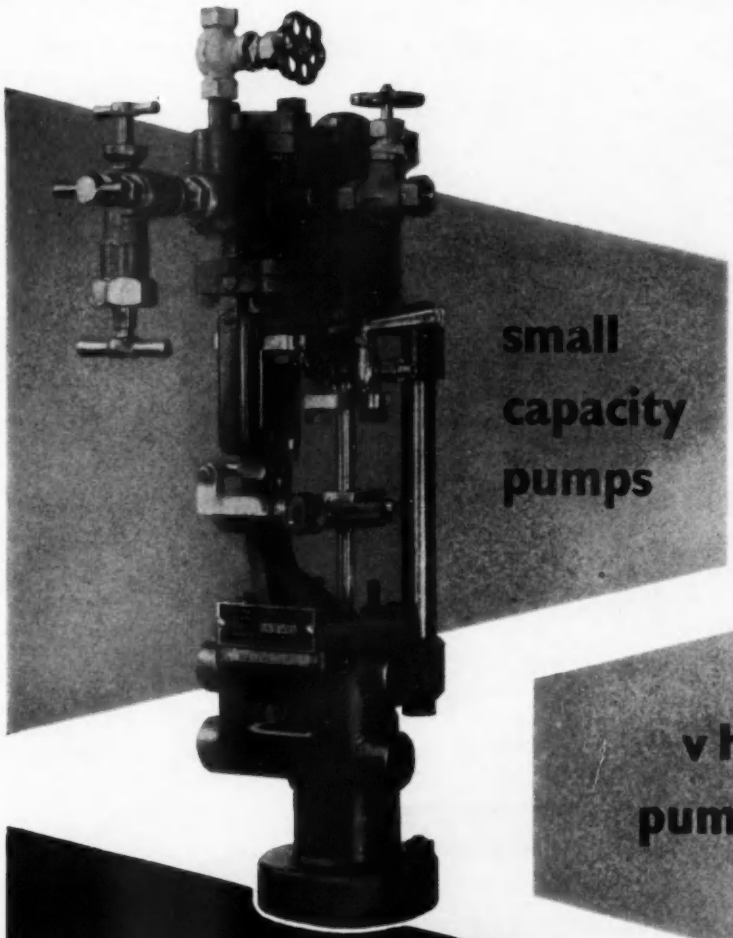
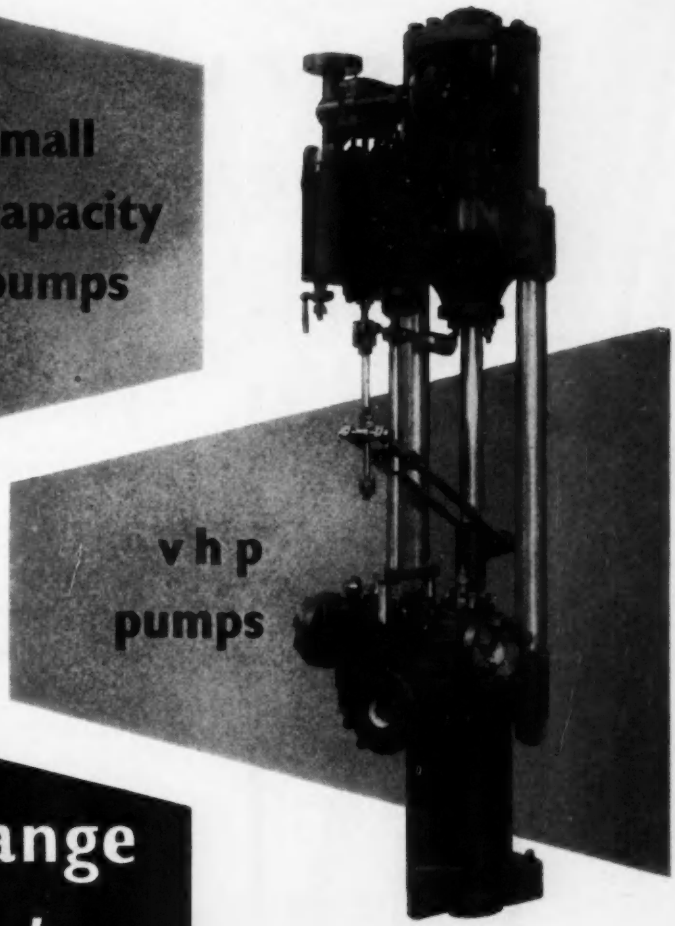


small capacity pumps



vhp pumps

a complete range for *boiler feed*

Hall pumps, the most efficient and economic steam pumps available, are specially designed to ensure that every unit of energy from steam is used before being passed to exhaust. The robust construction, steam piston valves and "built-up" type piston rings achieve long-life with low maintenance. Supplied in a wide range covering capacities from 100 to 10,000 gall. per hour, they are thoroughly tested before leaving the factory. Behind the world-wide reputation of Hall pumps lies nearly 60 years' experience of manufacturing and operating steam pumps.

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BOILER FEED PUMPS

J. P. HALL & SONS LIMITED *PETERBOROUGH* *TEL: 5306-7*

P.2960

Instrumentation in the boiler house

ensures correct conditions and fuel economy

Temperature . . .

Mercury-in-Glass, Mercury-in-Steel, Electrical; indicating and recording thermometers.

Draught . . .

Indicating and recording gauges.

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Indicating and recording gauges.

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Manufacturers of instruments for the indication, recording, controlling of : Temperature, pressure, liquid level, volume, specific gravity, humidity, etc.

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Main contractor; The General Electric Co. Ltd. (GEC/Simon-Carves atomic energy group)

The 320 MW Nuclear Generating Station now being constructed at Hunterston for the South of Scotland Electricity Board will employ 64 Hayward Tyler glandless motor pump units for its high and low pressure circulating systems.

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PROVIDING UNDER SEPARATE MANAGEMENT
A QUICK AND EFFICIENT SERVICE
TO THE MANY USERS
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In alloy or carbon steel,
for high or low pressure,
designed or to customer's drawings,
erected on site if required

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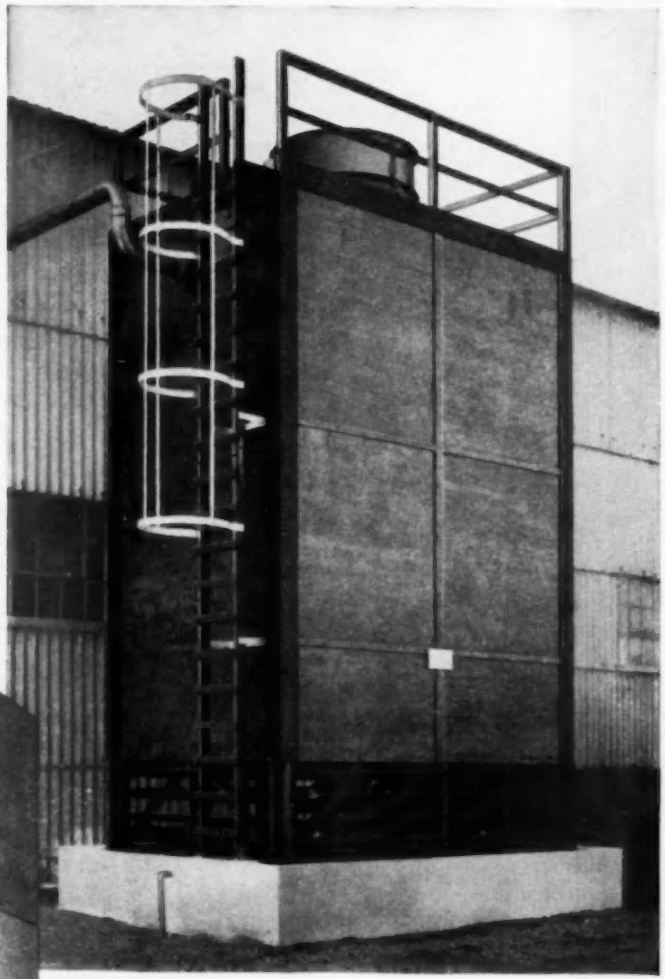
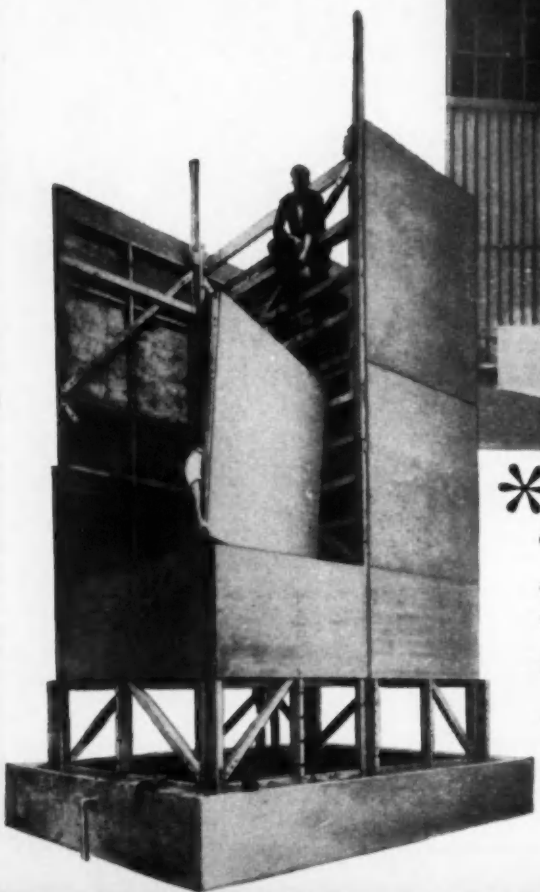
ALL ENQUIRIES FROM THE OIL REFINING AND PETROCHEMICAL INDUSTRIES SHOULD CONTINUE TO BE ADDRESSED TO OIL DEPARTMENT, 8 GOUGH SQUARE, FLEET STREET, LONDON, E.C.4

A **NEW** Induced draught
COOLING TOWER *by* FOSTER WHEELER

This 'D' Type Cooling Tower consists of a series of standard units with a cross sectional area ranging from 6'x6' to 16'x16' and designed to cool water quantities varying between 50 and 1500 Imperial gallons per minute.





The Cooling Tower is entirely pre-fabricated and can be easily erected by unskilled workmen.

- High exit air velocity prevents recirculation.
- Highly efficient heat transfer.
- Uniform air and water distribution.
- Draught eliminators ensure minimum water loss.
- Selected and treated timber for long life.
- Corrosion resistant hardware.
- Pre-fabricated for simple erection.

FWL/4

FOSTER WHEELER LIMITED

FOSTER WHEELER HOUSE, 3, IXWORTH PLACE, LONDON SW3. *Telephone: KENsington 6363*

66,000 HOURS' STEAMING—
66,000 HOURS' PRECIPITATION

That's the availability record of three Simon-Carves electro-precipitators which, helped by routine inspection and maintenance, have been collecting the flue-dust from pulverised fuel fired boilers at a C.E.G.B. generating station since 1955.

★ The three boilers have completed a combined steaming time of 66,000 hours.

★ At no time has a complete precipitator been out of action during the steaming periods.

★ The total time occupied by partial shut-downs—of individual zones, for minor repairs or inspection—is only about 200 hours.

★ On official tests the precipitators recorded efficiencies of 99.3% and 99.7%.

At generating stations, steelworks, chemical works and coal treatment plants you will find

HIGH-EFFICIENCY ELECTRO-PRECIPITATION BY

Simon-Carves Ltd

SIMON ENGINEERING GROUP

STOCKPORT, ENGLAND

and at CALCUTTA · JOHANNESBURG · SYDNEY · TORONTO

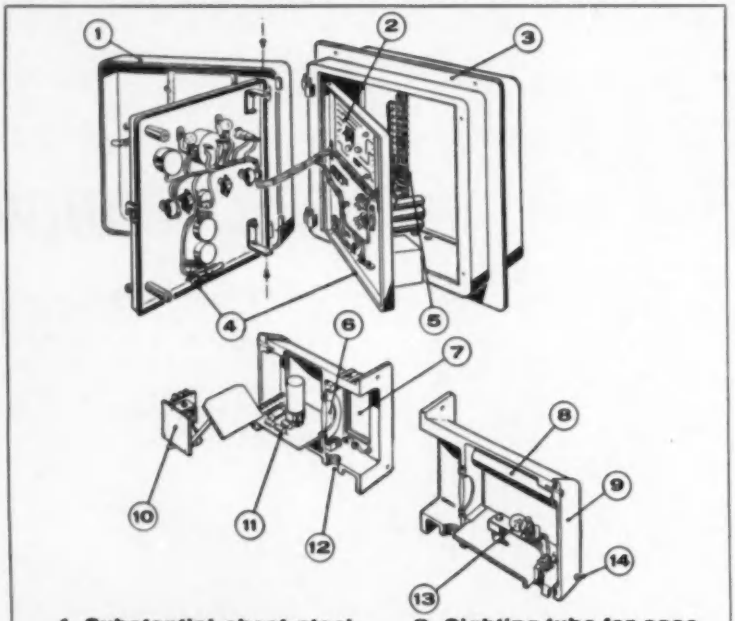
SC228

D

Now—you can ensure* *economic* protection against clean air act infringement—

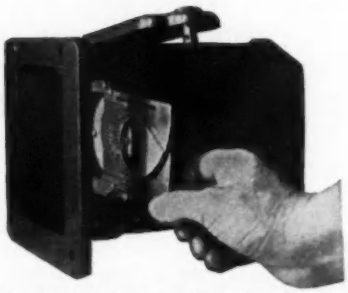
The Lancashire Dynamo Smoke Alarm protects you by warning when the Clean Air Act smoke limit is exceeded.

Priced at well under £100—yet engineered to the highest standards and manufactured and tested to rigorous specifications—the equipment offers a plus—simple conversion to smoke density indication for combustion control and fuel saving.



1. **Substantial sheet steel construction.**
2. **Printed circuit amplifier unit.**
3. **Optional flange mounting accessory.**
4. **Hinged leaf construction for ease of access.**
5. **Accessible external connections.**
6. **Rigidly mounted lens assemblies.**
7. **Easy access for lens cleaning.**
8. **Sighting tube for ease of alignment.**
9. **Solid cast iron construction with sealed covers.**
10. **Optional remote standardising accessory.**
11. **Withdrawable printed circuit card carrying photocell.**
12. **Entry for customer's conduit.**
13. **Simple rugged lamp mounting and adjustment.**
14. **Stainless steel fittings.**

Main unit showing locked away controls and calibration meter.



Calibration check by manual insertion of check slide.

*

This equipment is the first of its kind to carry the British Standards Institution's "Kite Mark", which indicates independent certification of compliance with BS.2740/56 or, plus the appropriate indicating instrument, with BS.2811/57.

In addition — from one source — all necessary installation accessories including chimney and flue fitments, indicators, recorders, alarm bells, horns, multicore cabling — write for full details.

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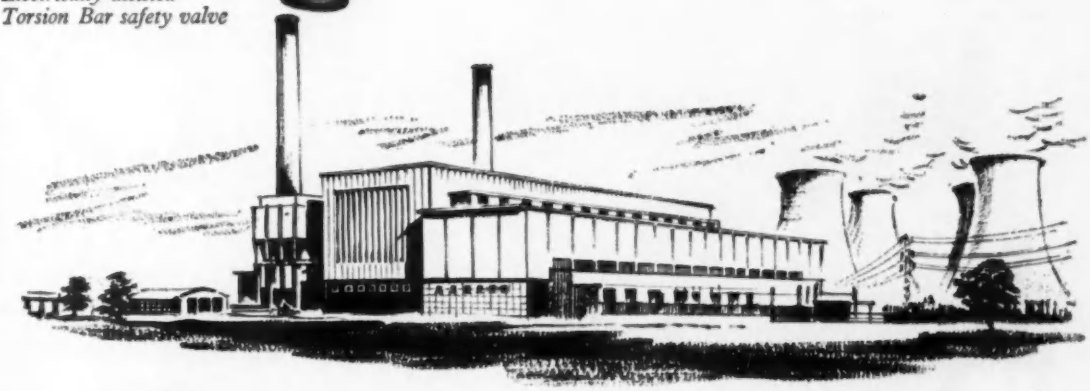
SP. 16b

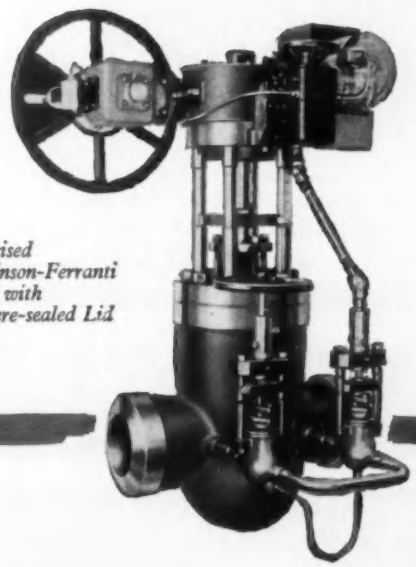
RUGELEY · STAFFORDSHIRE · ENGLAND

Manufacturers of the world's widest range of industrial electronic control equipment

HOPKINSONS' HIGH PRESSURE VALVES AT HIGH MARNHAM

Electrically-assisted Torsion Bar safety valve





Motorised Hopkinson-Ferranti Valve with Pressure-sealed Lid Joint

Yet another important power station operating at very high pressures and temperatures (2450 lb/sq. in., 1060 deg. F.) relies on HOPKINSONS' valves. Our supplies to High Marnham include :-

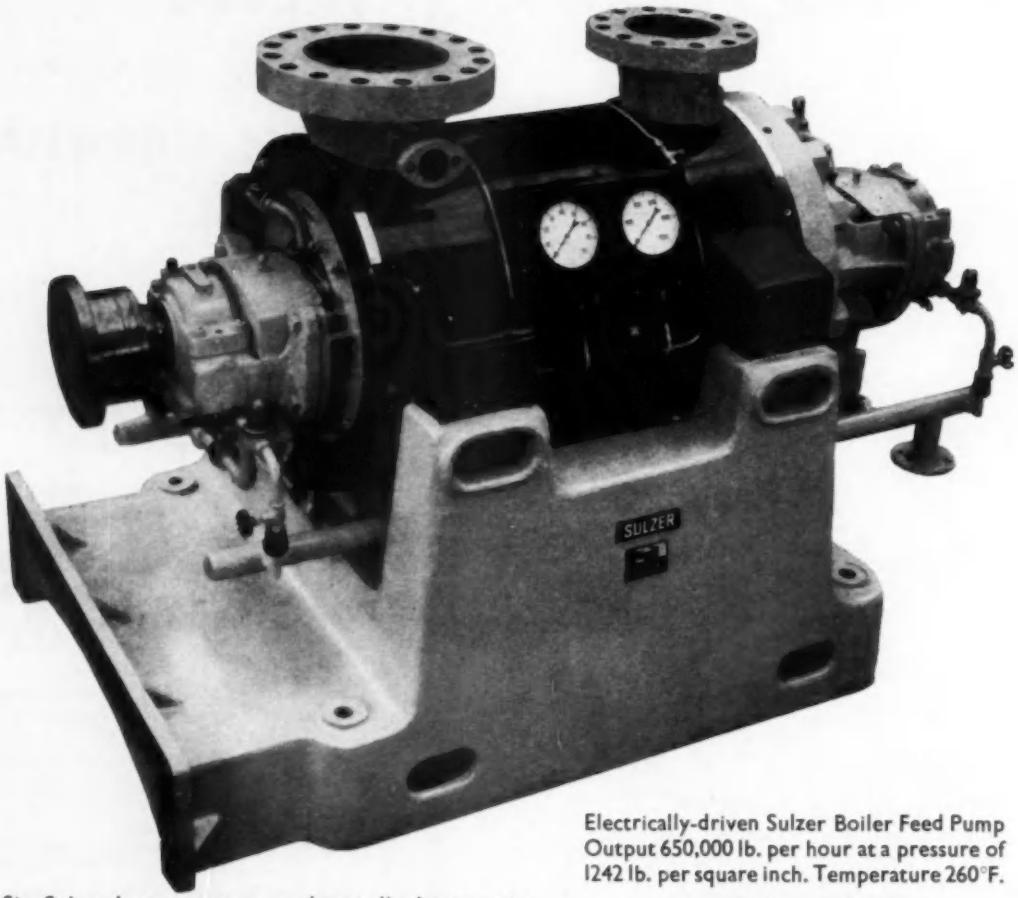
Torsion Bar safety valves
"Hylif" spring safety valves
Combined stop and non-return valves
Non-return valves
Parallel-slide valves
Hopkinson-Ferranti valves
Electric valve controls
"Uniflow" valves
Automatic isolating valves
Pump leak-off equipment
Strainers. Steam traps
Safety valve silencers and expansion chambers, etc.

HOPKINSONS LIMITED • HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET • STRAND • W.C.2

HV12

SULZER
BOILER - FEED PUMPS



Six Sulzer low temperature electrically-driven units each rated for an output of 650,000 lb./hr. have been supplied for the **CHAPELCROSS** installation of the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Electrically-driven Sulzer Boiler Feed Pump Output 650,000 lb. per hour at a pressure of 1242 lb. per square inch. Temperature 260°F.

one of nine units for

MARCHWOOD POWER STATION

of the

CENTRAL ELECTRICITY GENERATING BOARD

Complete range of Boiler Feed Pumps for nuclear and orthodox thermal plants including advanced class units.

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(INCORPORATING HATHORN, DAVEY & COMPANY, LTD.)

SULZER BROTHERS LIMITED HAVE OFFICES AT — WINTERTHUR · PARIS · NEW YORK · MADRID · CAIRO · RIO DE JANEIRO · BUENOS AIRES · KOBE · LISBON · JOHANNESBURG · MEXICO CITY
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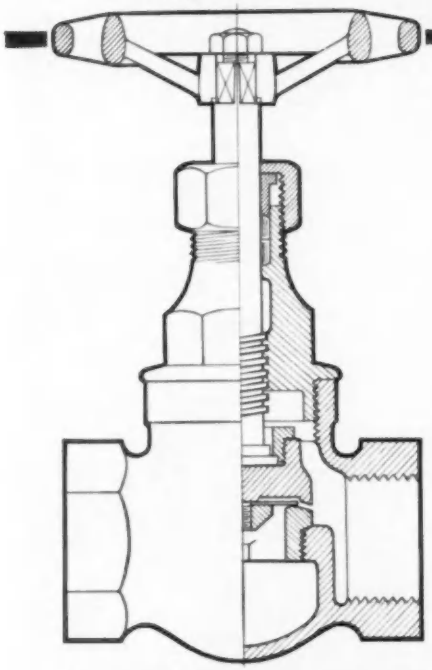
SINGAPORE · BANGKOK · RANGOON · SAIGON · MANILA · MONTREAL · BOGOTA · CARACAS · SANTIAGO (CHILE) · LIMA · LA PAZ · SYDNEY · MELBOURNE · WELLINGTON · VIENNA

News from Hattersley



the Fig. 2016 'PRESEATOR' globe valve with the Flexible Titanium Disk*

This specially designed Hattersley valve incorporates a flexible pre-seating disk made of an I.C.I. titanium alloy which is exceptionally resistant to corrosion and erosion. As this seats before the main surfaces, pipe-scale is trapped and the main seating surfaces protected from the effects of wire drawing.

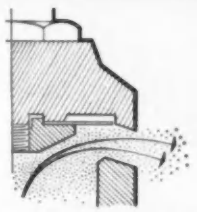
The broad-faced clack and its seat are of differing compositions of nickel alloy, giving differential surface hardness which prevents galling and seizure. There are many other fine features in this new design valve.

Suitable for steam at 200 lb. per sq. in. and 500° F.

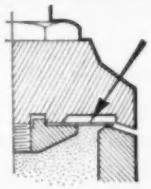
Please write for literature.

* *The Flexible Titanium Disk is protected by Patent No. 822147*

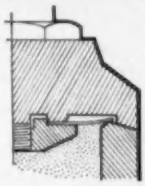
Over a period of years the outstanding merits of this Valve have been proved under the most arduous service conditions on many installations.



In open position free passage for flow directed across seating surfaces.



In 'Pre-shut' position flow and pipe scale held back by *Flexible Titanium Disk*. Patent No. 822147



Valve fully closed. Seating surfaces have passed through wire-drawing zone under virtually 'no-flow' conditions.

HATTERSLEY ESTABLISHED 1897

the name for good valves

HATTERSLEY (ORMSKIRK) LIMITED · ORMSKIRK · LANCASHIRE
and at HALIFAX and LONDON

H.2

Guaranteed SMOKELESS COMBUSTION

with the new

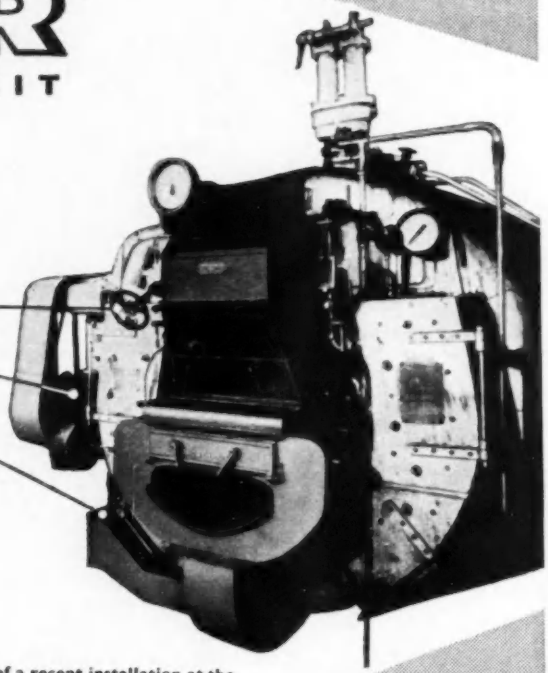
"CL'AIR"

COMBUSTION UNIT

Patent Applied For

FLEXIBLE

Control of fire thickness
Control of Grate Speed
Control of Forced Draught



ECONOMICAL

Low maintenance costs. No Stoker working parts. High Efficiency Self Cleaning Grates. Designed for Low Grade fuels.

Part of a recent installation at the St. Lawrence Hospital, Chepstow.

(Photograph by courtesy of the Hospital Authorities)

GUARANTEED

Smokeless combustion
Grit Free Operation
Full boiler rating.

CUT COSTS WITH

CROSTHWAITE

FORCED DRAUGHT FURNACES, AUTOMATIC STOKERS AND COAL & ASH HANDLING PLANT

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Telephone 3-2411 & 2

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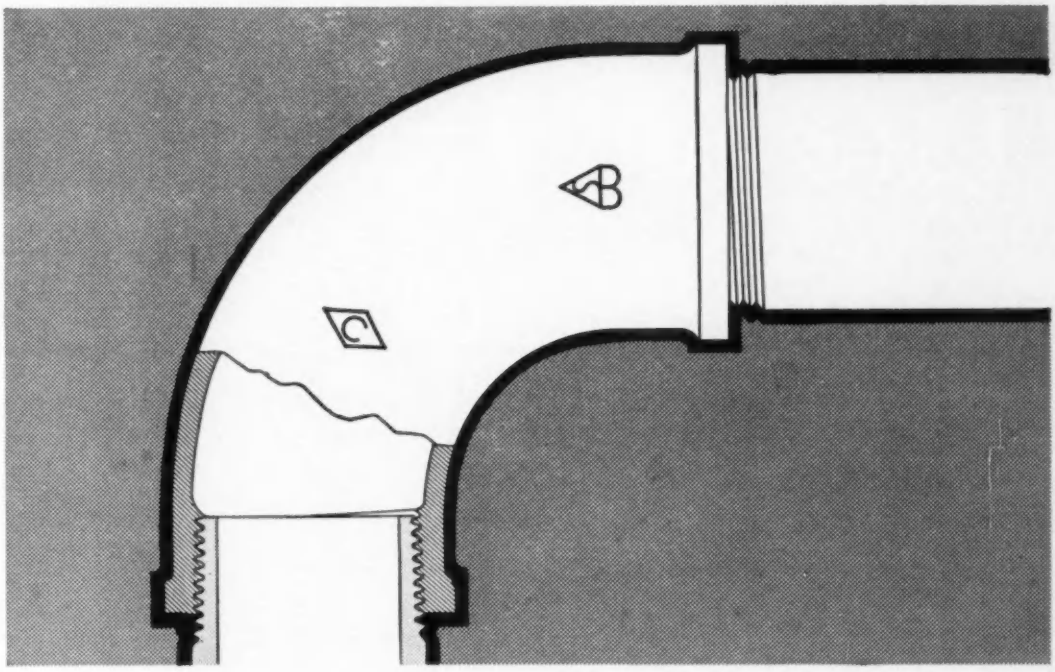

Why is it easier to make these joints pressure tight?

Because they are made with the taper threads of Crane Malleable Iron Pipe Fittings. All Crane Pipe Fittings made to British Standard 143 have taper threads, which not only make a more efficient, tighter joint, *but eliminate the need for hemp packing.* Hence, a cleaner finish and better all-round appearance.

Every fitting is tested. Crane Pipe Fittings are highly dependable because they are inspected during manufacture and each one is individually pressure tested at the Crane factory where it is made. They give exceptionally long and trouble-free service.

A full versatile range. Crane Pipe Fittings, both plain and banded patterns, are made in many types; they range in size from $\frac{1}{8}$-inch to 6-inches, equal and reducing. If you would like full details, please write to us at the address below.

THE TAPER THREAD IS AN OUTSTANDING FEATURE OF

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MALLEABLE IRON PIPE FITTINGS

Crane Ltd., 15-16 Red Lion Court, Fleet Street, London, E.C.4
Works: Ipswich. Branches: Birmingham, Brentford,
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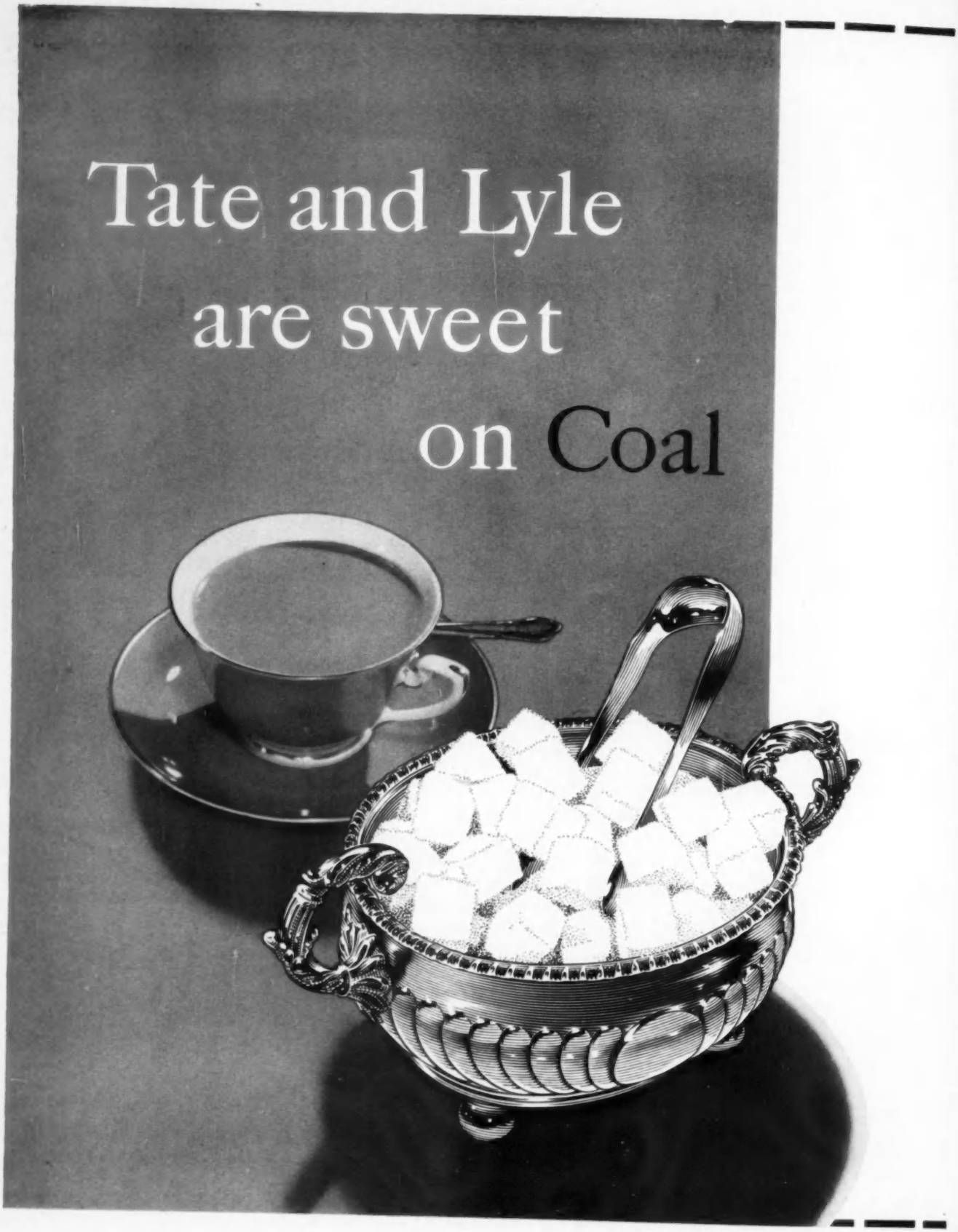
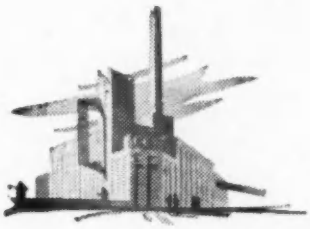

Tate and Lyle
are sweet
on Coal



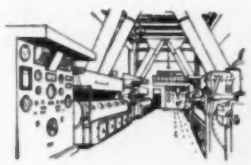
TROPICAL PLANTATIONS for cane sugar, English fields for sugar beet. And, for Tate and Lyle, British coal to begin the processes that put an endless supply of pure sugar into the larders of Britain.

The shrewd men who direct this great sugar business choose coal because coal, efficiently burned on mechanical stokers, provides accurately controlled heat for the lowest cost per lb. of steam; because coal—mechanically stoked—burns smokelessly; and because the coalfields of Britain can supply all industrial demands for generations to come.

When it's your turn to make a decision about fuel, remember Tate and Lyle. Their experience could profitably sweeten your financial cup of tea.

Here are some key facts and figures about the Tate and Lyle power houses at their refineries in London and Liverpool

The boiler houses at the three Tate and Lyle refineries raise together 890,000 lbs. of steam per hour at 650 lbs. per sq. inch at 82% efficiency, which pass through turbines to generate 24 Mw. of electricity of which 4 Mw. is re-exported to the grid. The steam then goes to the process, and the power and heating operation has an overall thermal efficiency of 72%. The coal burnt amounts to over 300,000 tons per annum of washed smalls.



PROGRESSIVE INDUSTRY IS GOING FORWARD ON

COAL

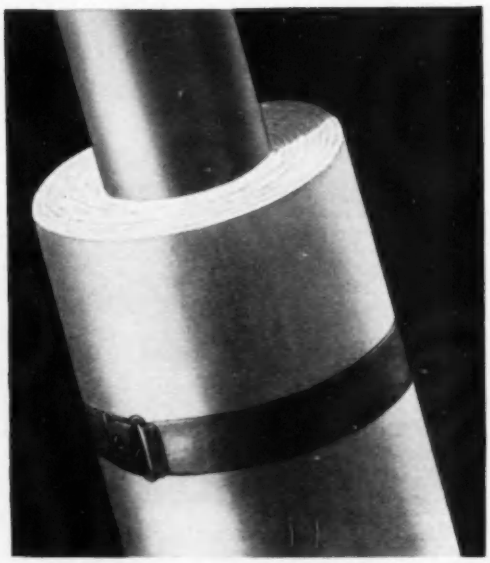
ISSUED BY THE NATIONAL COAL BOARD

"I was Cool, Man, Cool!"

'Steamy' Pipe reminisces

"It's my job to carry steam — and to keep it at s-s-s-steam heat. But I was falling down on the job — as flat as an old-fashioned waltz at a Rock 'n Roll Rally. I was losing heat. Wasting fuel. Throwing away money. If I hadn't been so round, you could have called me a square.

What a difference when they fitted me from top to toe in Fibreglass Rigid Sections! Man, these sections are really something! They're light; they're trim; they go on easily and stay on permanently. Since they came along, I've been the savingest pipe in the business; *and* I keep the steam just as it should be — piping hot!"

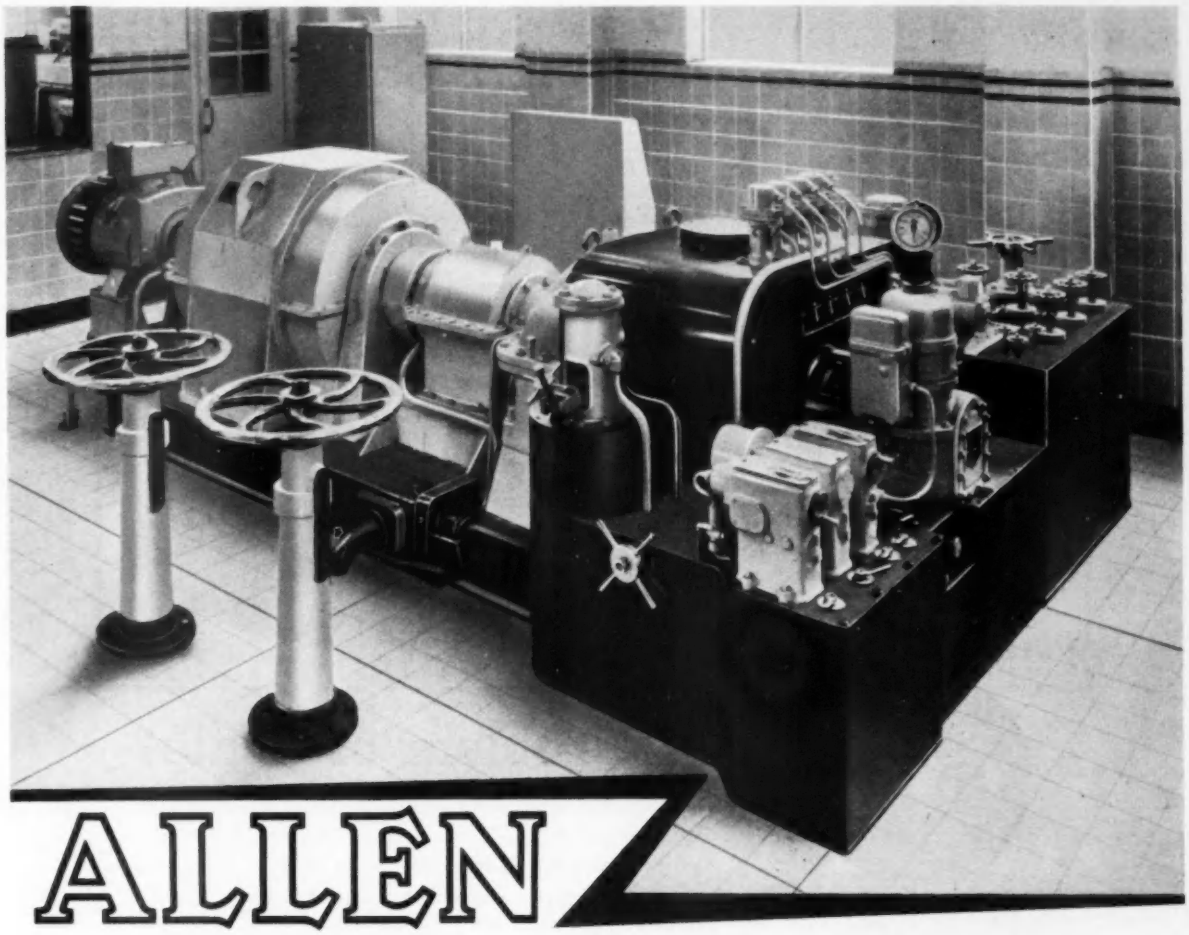


FIBREGLASS
TRADE MARK

"Rigid Sections are the most"

'Steamy' Pipe proclaims

FIBREGLASS LIMITED, ST. HELENS, LANCASHIRE · ST. HELENS 4224



ALLEN

TURBINE POWER PLANT

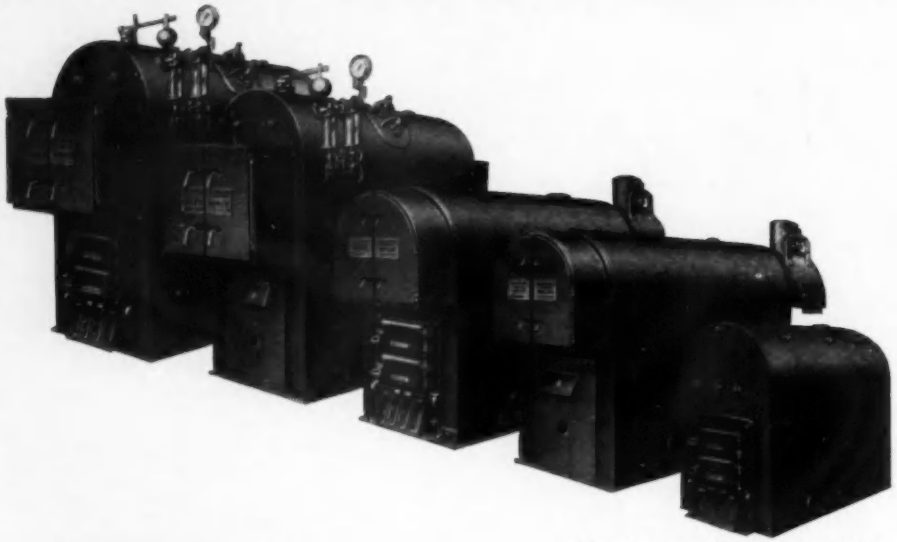
. . . *for industrial service* . . .

The turbo-alternator set illustrated supplies the electric power requirements of the Cambridge Gasworks (Eastern Gas Board), and is also arranged to run in parallel with the public electricity system.

The set comprises an Allen pass-out condensing steam turbine running at 9000 r.p.m., driving a 500 kW alternator at 1500 r.p.m. through epicyclic gearing. The turbine is fitted with inlet-pressure governing and pass-out pressure control and operates with steam from waste-heat boilers at 180 p.s.i.g. and 600° Fahr. It also provides up to 4000 lb. per hour of pass-out steam at 20 p.s.i.g. for retort steaming and by-product recovery plant.

Specialists in complete industrial power generating plant installations

W. H. ALLEN SONS & Co LTD BEDFORD



Boilers by Hartley & Sugden Ltd., Halifax

A section of copper piping showing heavy scale deposit

The same section after treatment with Starit

A Problem of Scale?

Is there a falling-off in steam raising? Do you suspect metal stress, or serious loss of heat during transfer from fuel to water? These and kindred questions in connection with boilers and feed pipes can be an indication of scale deposit that lowers the efficiency so vital to economical steam raising.

Starit effectively removes most types of scale from boilers and feed pipes, attacking and dissolving the scale to leave the metal in a first-class condition of conductivity. The action of Starit ensures rapid removal of scale deposit, but its effect on boiler plates is inhibited. Starit solution is especially effective for cleaning awkward corners impossible to reach by hand.

Starit is successful in most cases of scale deposit, but as some scale is immune to chemical treatment, send us a sample. We will then determine the suitability of Starit for your particular problem and send you a booklet dealing with the uses of Starit and methods of its application.

The solution is STARIT

TRADE STARIT MARK

STARIT LIMITED DARWEN · LANCS

New

Type A Actionator motors are ideal for rotary plug valves, dampers, butterfly valves, etc. Features include internal brake and micro switch limit switches.

ACTIONATOR

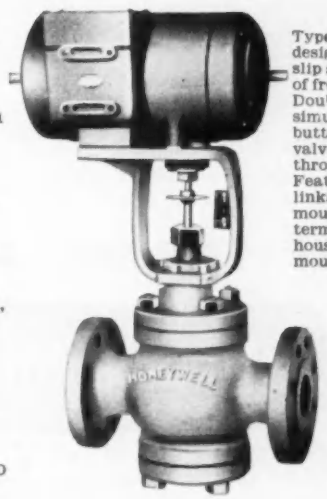
heavy duty electric motors for valves and dampers

Use the powerful new Actionator industrial type motors to operate slip stem valves, rotary plug valves, butterfly valves, dampers, etc.

Variety of speeds
Actionator motors are available with a variety of speeds, from 9 to 144 seconds full-stroke operation. The high speed permits use with pulse-type controllers such as those used in radiant tube firing. Torque ratings range to 200 lb-inches.

All control forms
Models are available with two-position, floating and proportional control. Optional models can include cam-operated, internally mounted switches for a variety of dual switching purposes.

Write Now
for more details, or send the coupon to Honeywell Controls Limited, Ruislip Road East, Greenford, Middlesex. WAXlow 2333. Branch offices in principal towns and cities of the United Kingdom — and throughout the world.



Type B Actionator motors are designed for vertical acting slip stem valves having lifts of from ¼ inch to 1¼ inches. Double ended shaft can also simultaneously operate butterfly valves, rotary stem valves and other devices through suitable linkages. Features include built-in linkage and strain relief, mounting yoke and enclosed terminals with gasketed housing. No auxiliary mounting bracket required.

Honeywell

First in Control

SINCE 1885

Please send me a copy of:
Specification Sheet S804-3 (Type A) ☐
Specification Sheet S1016-2 (Type B) ☐

NAME.....

POSITION.....

ADDRESS.....

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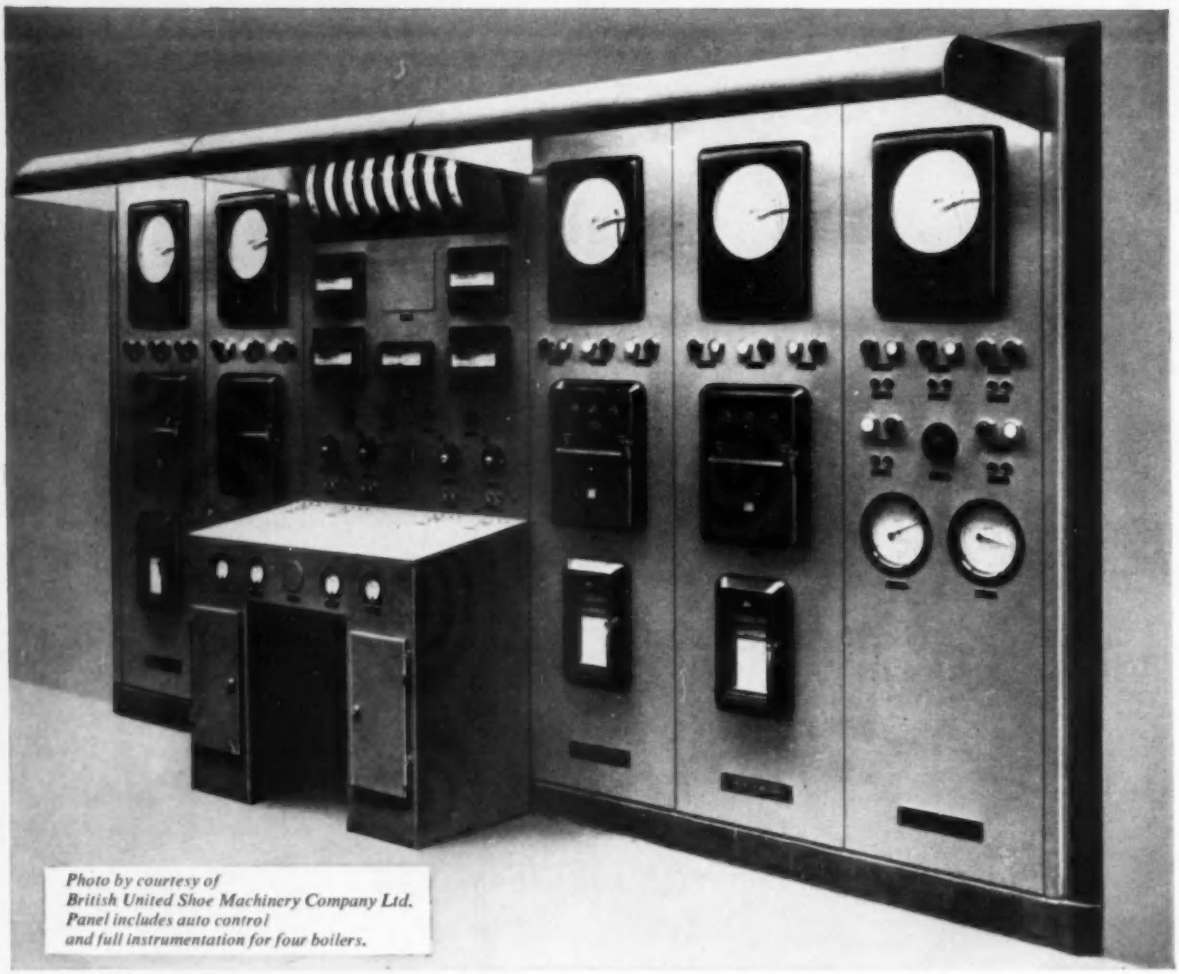

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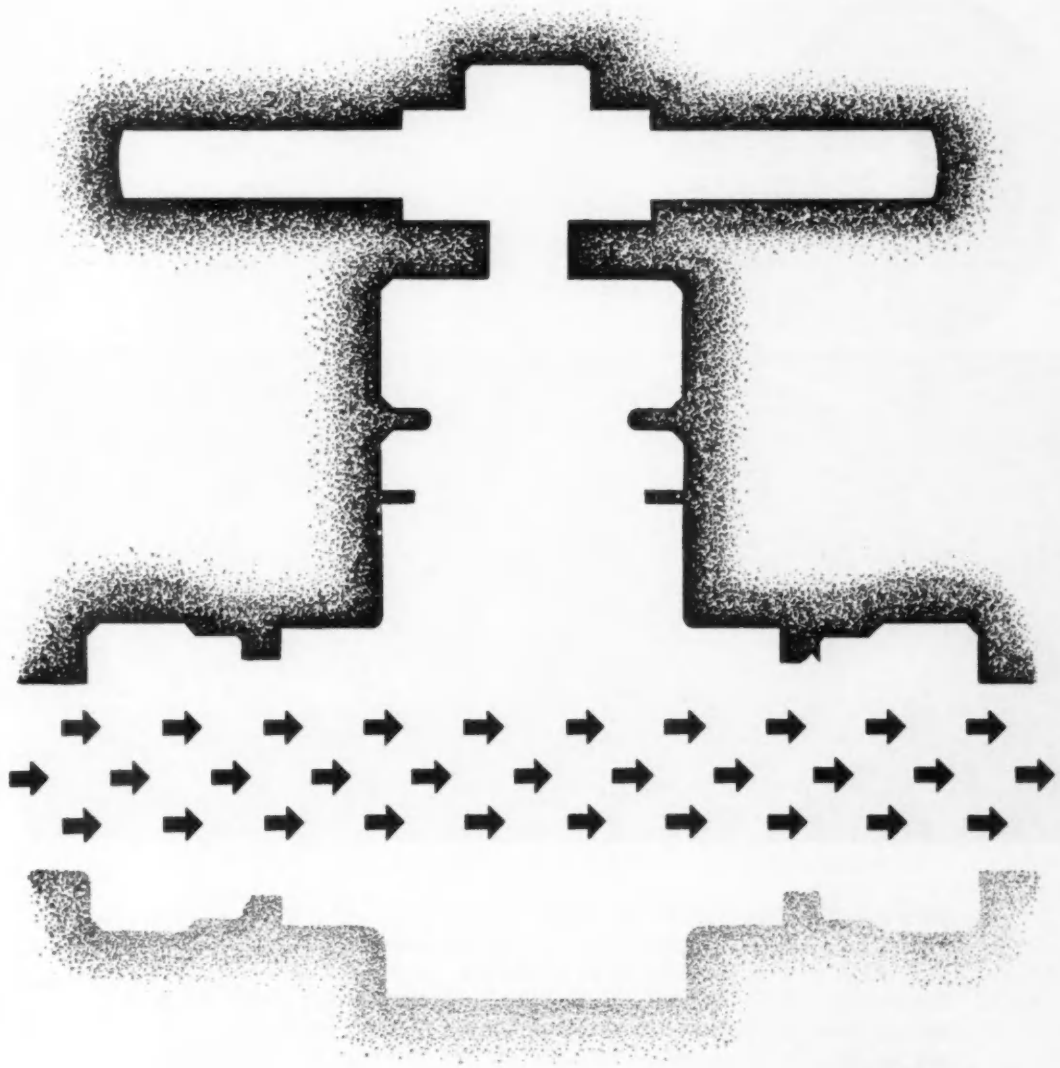

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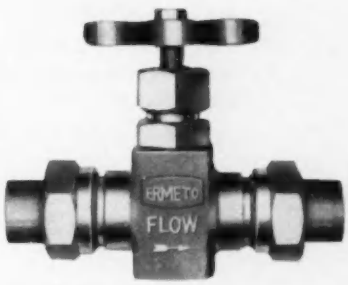

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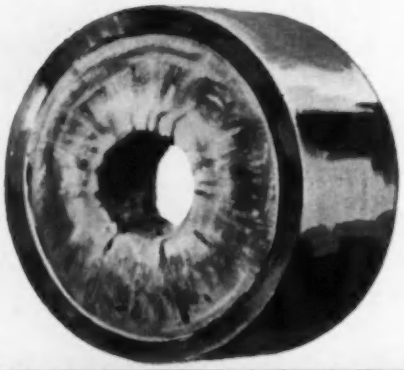

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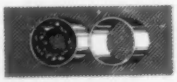

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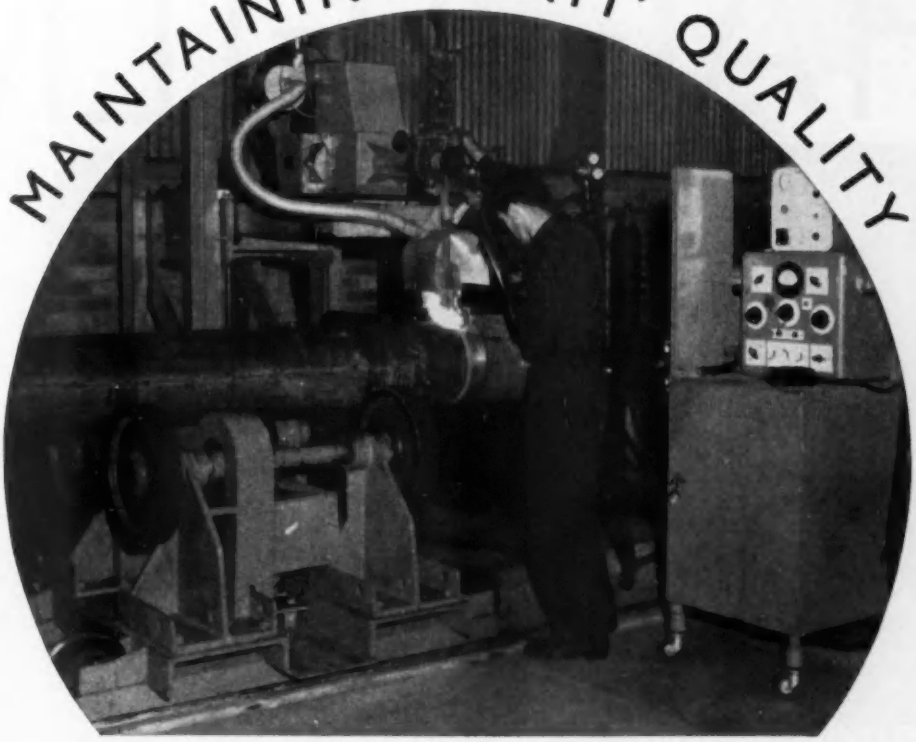

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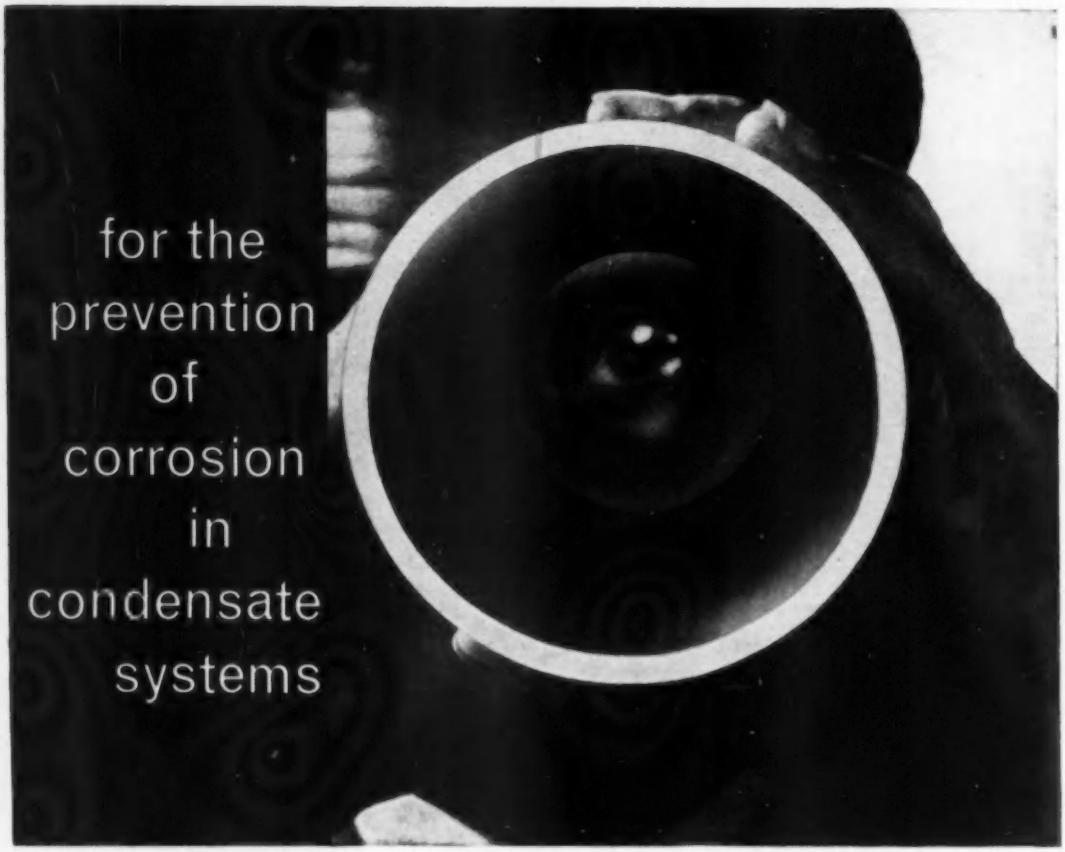

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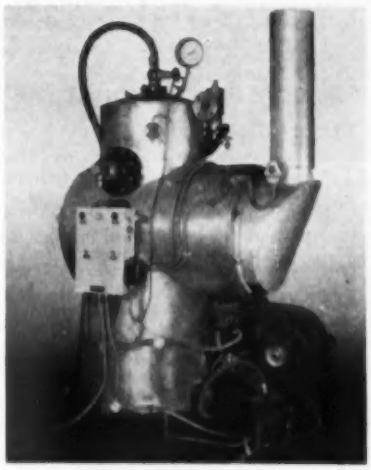

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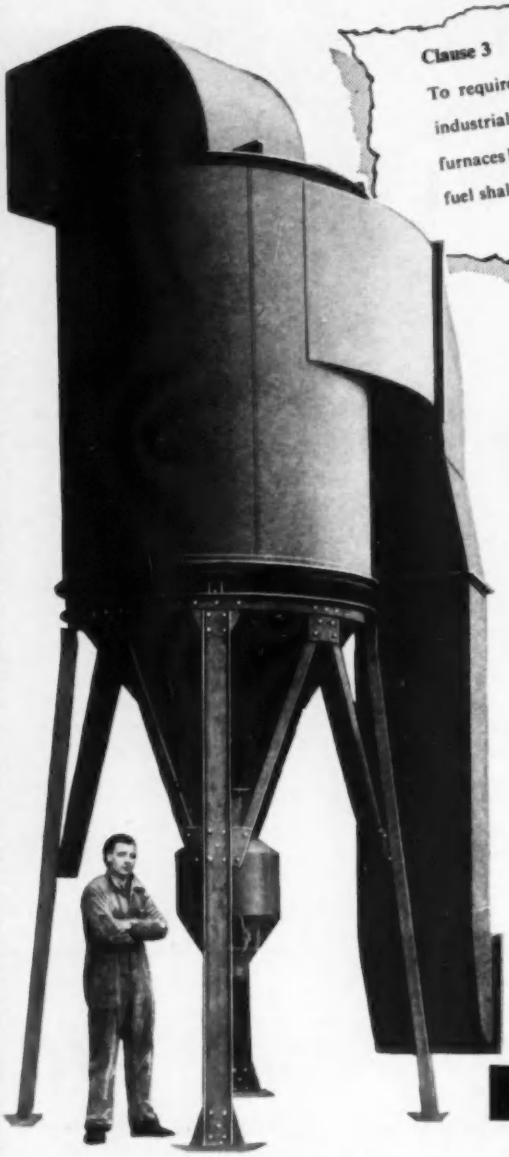

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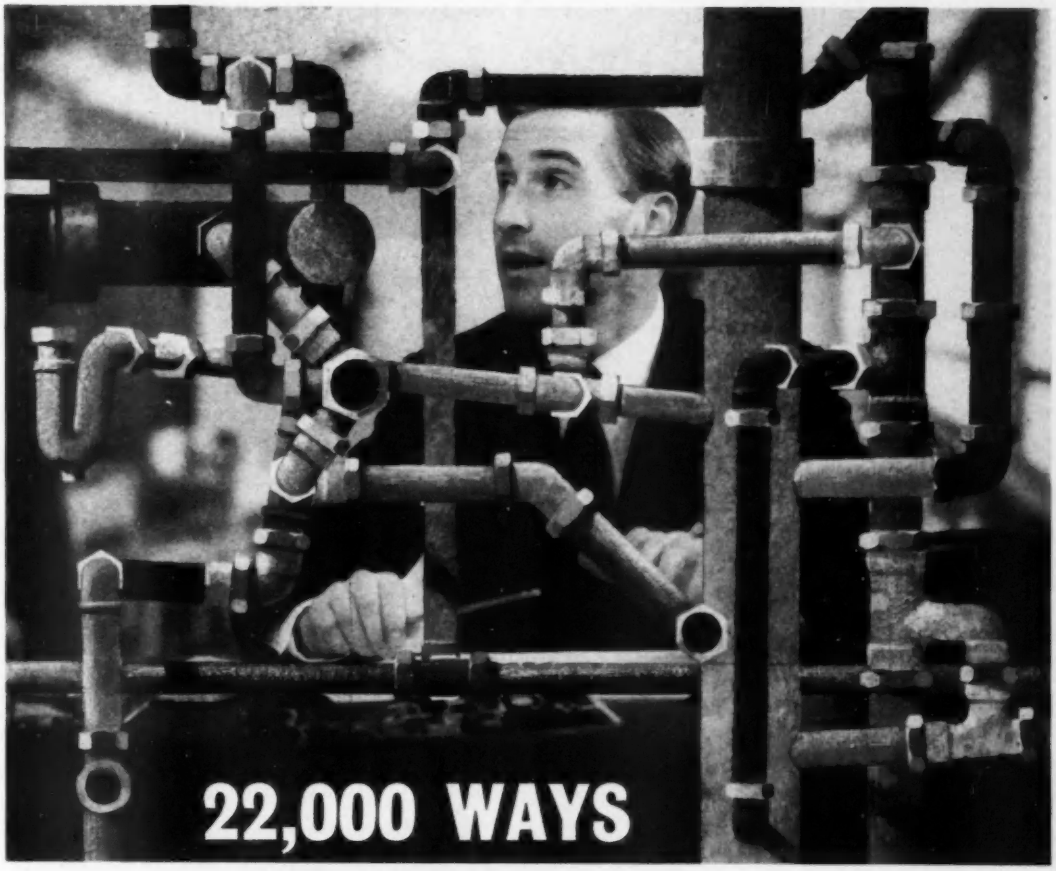

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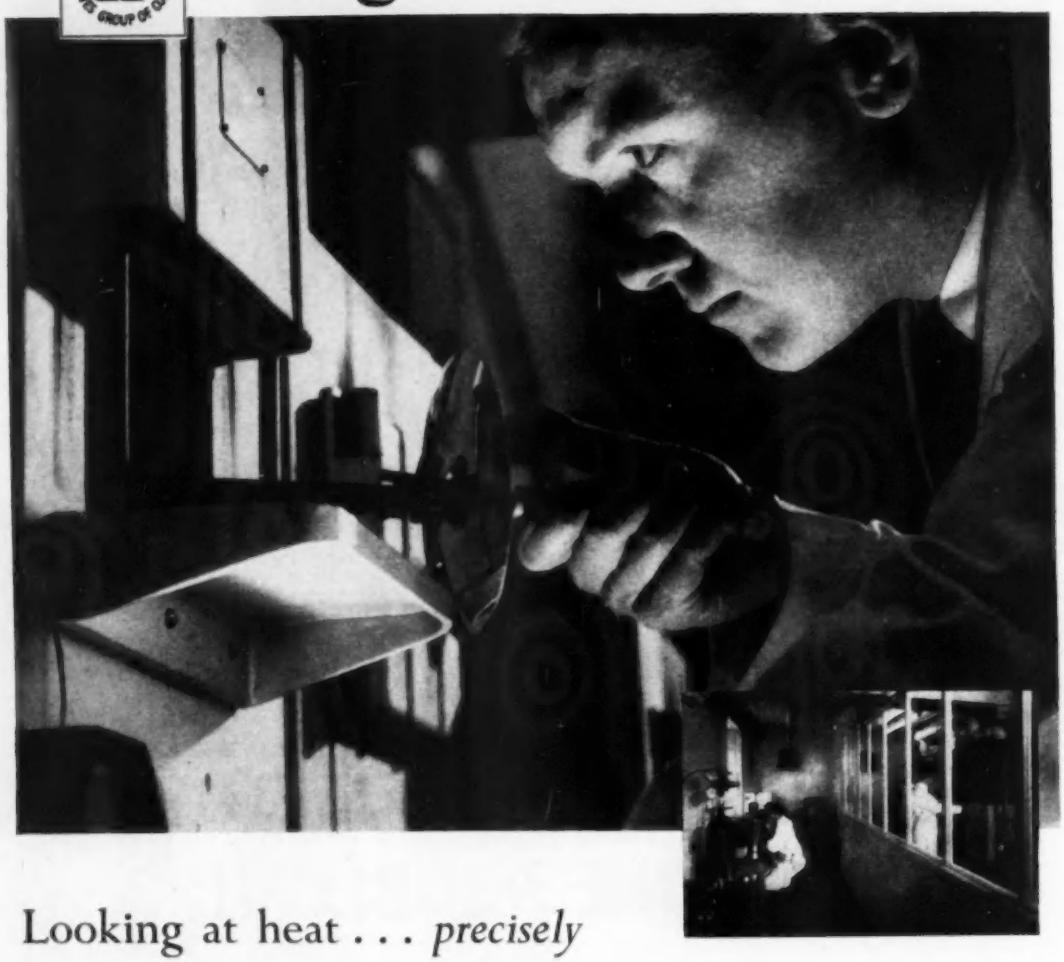

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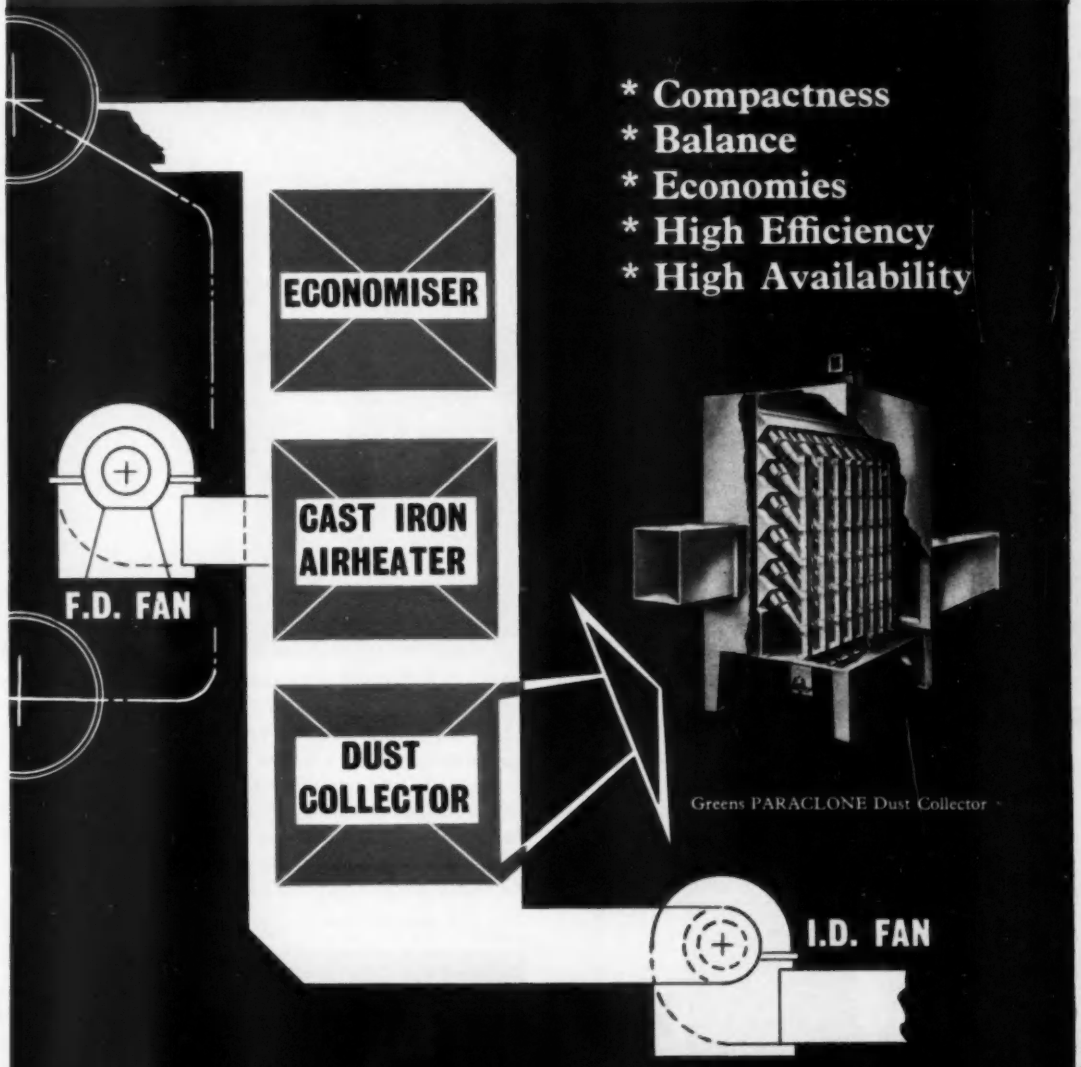

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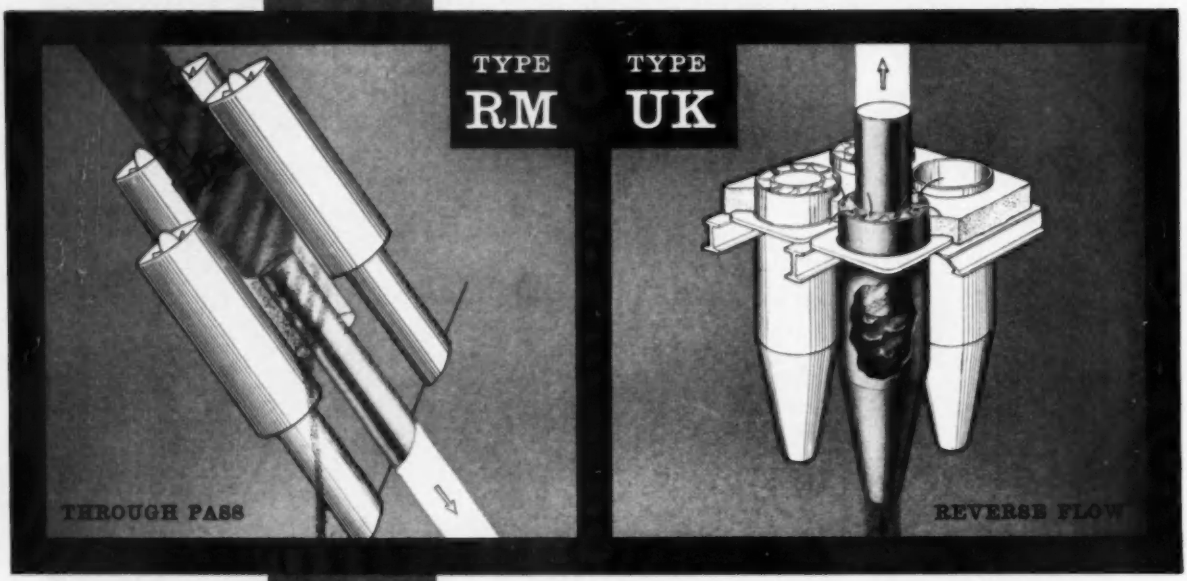

Holmes-Rothemuhle Multi-Cell Cyclone Dust Collectors are the answer to many of the problems involved in the collection of dust and grit particles in the higher size ranges (ten microns and above). In addition to the advantages of low installation, operating and maintenance costs, these collectors have the added advantage of space saving construction which enables them to be easily fitted into existing flue-gas ducting.

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A. 946

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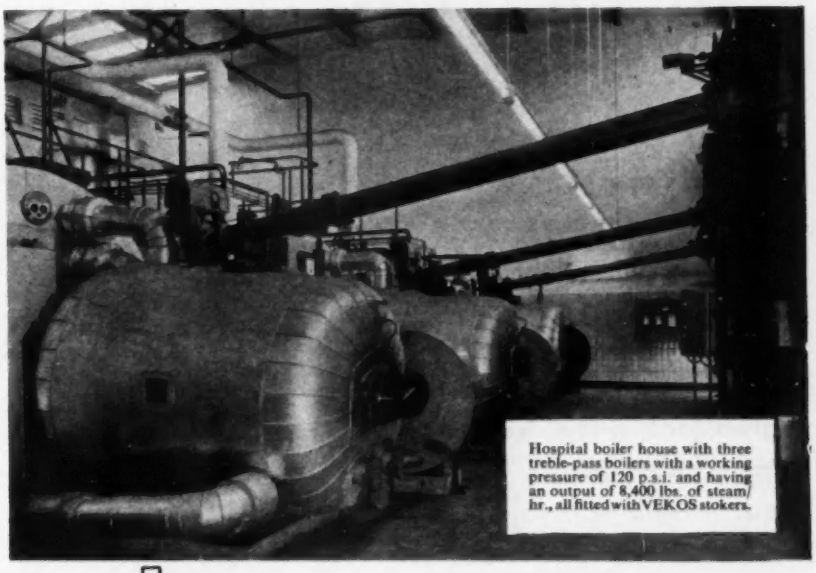
Fully descriptive leaflet VE.759 will be sent on request, and our Engineers are ready to discuss its application to your own particular installation.



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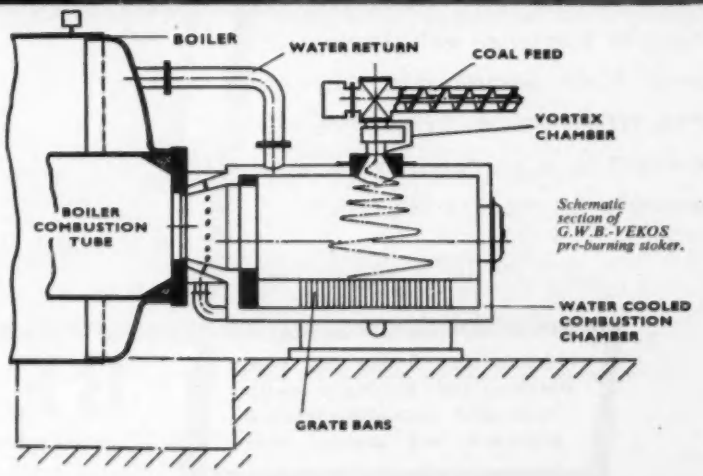

Schematic section of G.W.B.-VEKOS pre-burning stoker.

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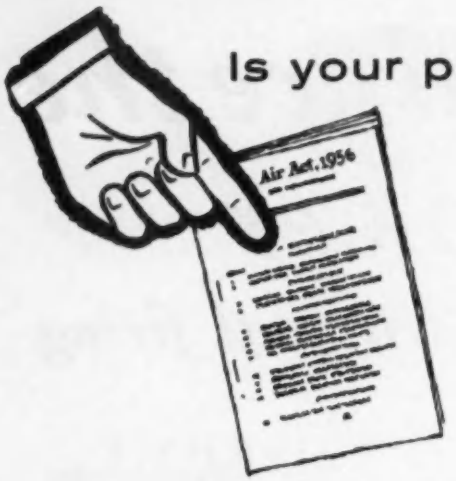

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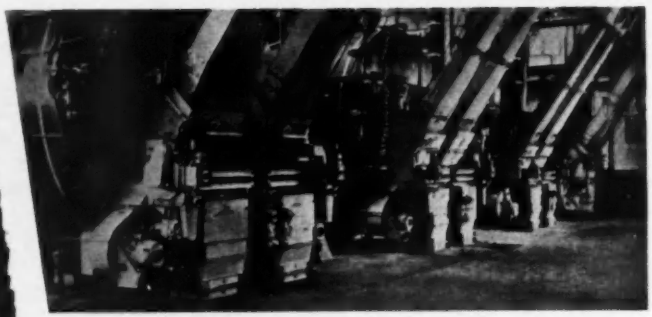

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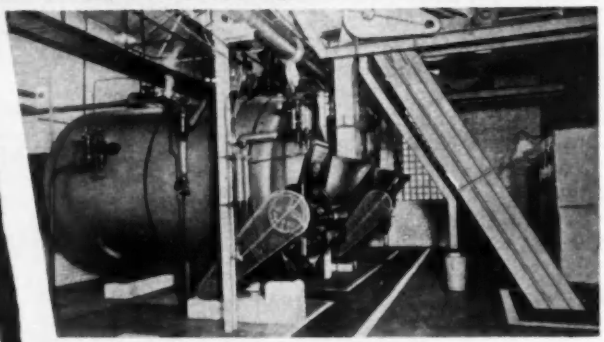

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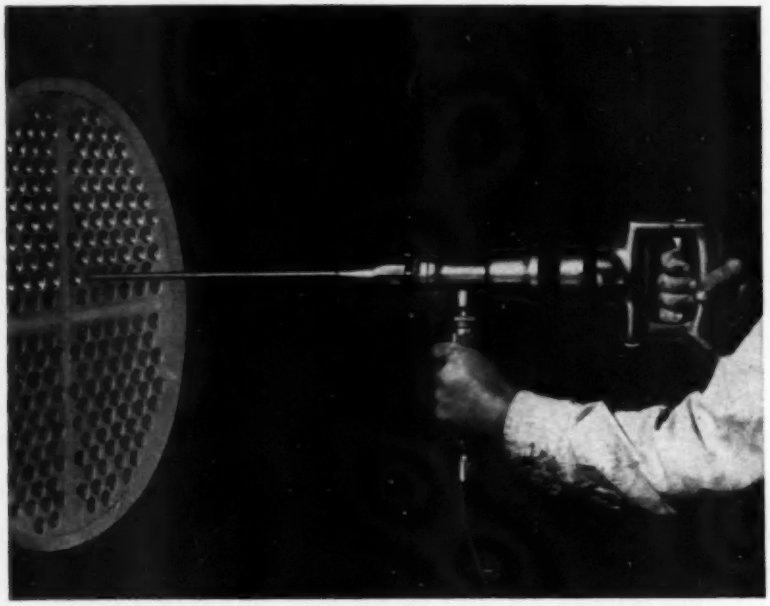

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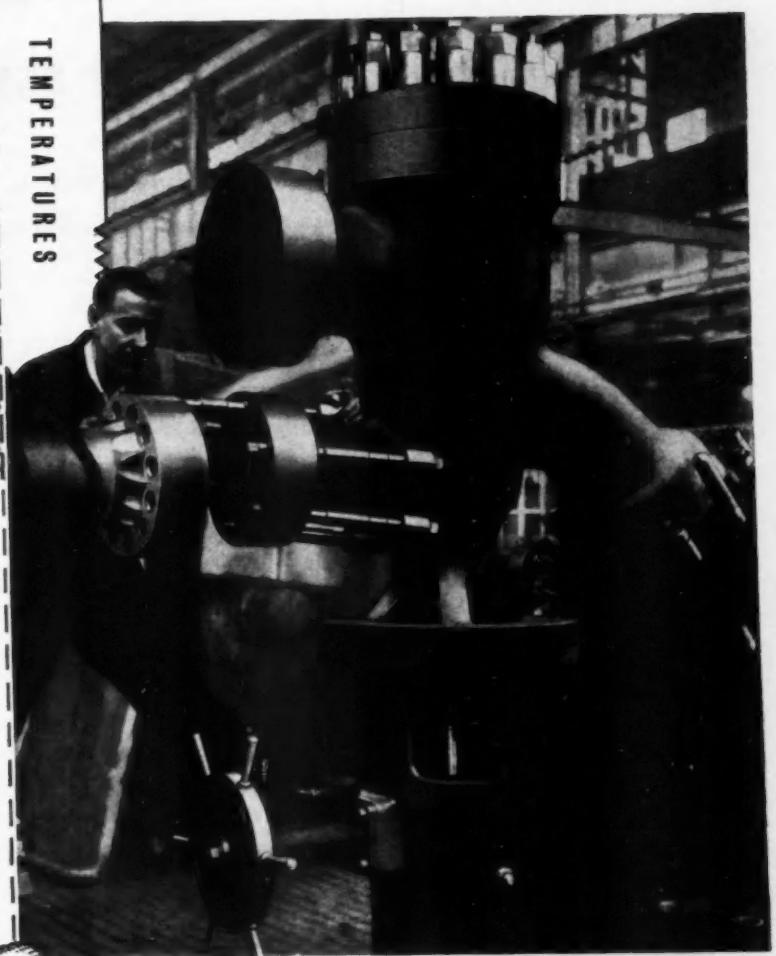

Special bolts made in CHROMVA-W Steel used on a stop valve for a high pressure steam turbine. Initial temperature 1050°F. at 1500 lbs. per square inch.

Photograph by courtesy of A.E.I. Ltd., Turbine-Generator Division, Rugby.

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Engineering and BOILER HOUSE REVIEW

THE OLDEST ESTABLISHED STEAM ENGINEERING PUBLICATION

MARCH 1960

VOLUME 75. No. 3

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Babcock Radiant, reheat type, pulverized-fuel-fired, with an evaporation of 3,750,000 lb./hr. at 2400 lb./sq. in. 1055 F, for THORPE MARSH power station, Central Electricity Generating Board.

300 MW

Radiant, reheat units, pulverized-fuel-fired, for WEST THURROCK power station.

200 MW

Radiant units, pulverized-fuel-fired, for WEST THURROCK, WILLINGTON 'B' and KINCARDINE (with reheat); and HAZELWOOD (Australia).

100 MW TO 125

Radiant, reheat units, pulverized-fuel or 'Cyclone' fired, of capacities from 100 to 125 MW, for BLYTH 'A,' RUGELEY, USKMOUTH 'B,' PADIHAM 'B,' FERRYBRIDGE 'B,' ASNAES (Denmark), PONT BRULE, FARCIENNES and MOL (Belgium), TIRRENA and CHIVASSO (Italy), KAWASAKI (Japan) and YALLOURN (Australia); also the six 100 MW units at CASTLE DONINGTON power station, which topped the efficiency table in 1959.

Central station boiler development in recent years has been remarkable for the steep rise in unit capacities, with parallel advances in steam conditions and the extensive use of reheat; achieving valuable gains in thermal efficiency. This development reflects intensive progress—in design, engineering and manufacture—by the BABCOCK organization, which has supplied, or is currently manufacturing, a considerable number of boilers of from 100 to 300 MW capacity, and which is now to supply a unit of 550 MW capacity—the first to provide this huge output from a single-furnace natural-circulation design.

BABCOCK

STEAM-RAISING PLANT

BABCOCK & WILCOX LTD., BABCOCK HOUSE, 209 EUSTON ROAD, N.W.1

Engineering and
BOILER HOUSE REVIEW

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THE FUEL & POWER INDUSTRIES AND NATIONAL PROSPERITY

IN the first of three Cantor lectures under the above title, given by Dr. Albert Parker, C.B.E. (formerly Director of Fuel Research, D.S.I.R.), to the Royal Society of Arts on February 15th, the lecturer pointed out that experience over the last hundred years has clearly shown that the effective use of fuel and power in overcoming climatic disadvantages, in producing agricultural fertilisers, in manufacturing materials of many kinds, and in replacing and greatly augmenting human labour has been a major factor in raising the standards of living of the peoples of many nations to an extent that even fifty years ago would have been considered impossible. In the great material progress that has been made, fuel and power have been particularly important in countries such as the United Kingdom with a population so large in relation to the area of fertile land, that much of the food required has to be imported. Mechanisation and industrial development based on fuel and power have enabled good use to be made of the ability and skill of the people in producing manufactured goods for export, so that payment could be made for the necessary imports of food and of raw materials for industry. Statistics provided in tabular form by Dr. Parker show that in the cases of nine of the leading countries of the world with a decrease in the consumption of fuel and power per inhabitant, there is a decrease in the average income per inhabitant, thus illustrating the importance of fuel and power as a factor in national prosperity.

According to available information, the probable world reserves of bituminous coals and anthracites are about 4 million million tons, and the probable reserves of brown coals and lignites are about 1 million million tons. This gives a total for all coals and lignites of 5 million million tons—equivalent in thermal value to about 4½ million million tons of bituminous coal, of which 1 million million tons have been proved. It appears that one-third of the estimated world reserves of coals and lignites are in the U.S.A., one-quarter in the U.S.S.R., and nearly one-quarter in China, leaving only about one-fifth for the rest of the world, which has nearly two-thirds of the world population of 2,900 millions. It is, however, emphasised that in estimating these figures, only those seams have been included that are believed to contain at least 1-ft. thickness of coal or lignite at a depth below the surface of not more than 4,000 ft., for bituminous coals and anthracites, and not more than 1,650 ft. for brown coals and lignites. For some areas only thicker and shallower seams have been considered.

As regards petroleum, Dr. Parker pointed out that on several occasions during the last fifty years, it has been predicted that at the expected rates of production, the oil resources of the world would be exhausted within 15 or 20 years. These predictions have all been proved incorrect, for though the rate of production has increased more rapidly than was expected, new reserves have been discovered, and the estimates of remaining resources have been steadily increased. Twenty years ago, the proved reserves of petroleum for the world were estimated to be about 5,500 million tons. Since that time, the world has used about 11,000 million tons, yet production still continues at an increasing rate. A year ago, the estimate of the proved reserves was about 37,000 million, or about forty times the present annual rate of consumption of petroleum oil. Of the estimated proved reserves, 62 per cent. are in the Middle East, 13 per cent. in the U.S.A., 7 per cent. in South and Central America, and 10 per cent. in the U.S.S.R., leaving only about 8 per cent. for the rest of the world. But it is certain that the further intensive explorations that are being made will lead to the discovery of other reserves of petroleum oil. Consideration of promising geological formations suggests the possibility of discovering additional oil reserves in the region of 70,000 million tons, or about twice the present estimate of proved reserves, making an overall total of possible and proved reserves of about 100,000 million tons. This quantity is equivalent in thermal value to about 150,000 million tons of bituminous coal. There are, of course, other deposits and gases which must be considered in terms of their equivalent thermal value to bituminous coal. These are natural gas, oil shale, peat, etc. Figures from available estimates of the probable and possible energy resources of the world in the form of fossil fuels show that estimated reserves of all these fuels together are equivalent to nearly 5 million million tons of bituminous coal. Of this quantity, 92 per cent. occurs as coals and lignites and 6 per cent. as petroleum, natural gas, and methane in coal measures.

In making reference to atomic energy, Dr. Parker pointed out that Uranium is the source of energy from nuclear fission being used and developed at the present time, and that Thorium could similarly be used. From estimates so far made of the world resources of ores sufficiently rich in uranium and thorium to be economically worked, it seems that their energy value is much greater than that of the estimated reserves of coals and lignites, probably at least 25 times as great. There is also the possibility of the development of almost unlimited amounts of energy from nuclear fusion.

Other interesting statistics given in the lecture concern world consumption of the principal forms of fuel and energy during the year 1958, when world population was about 2,850 millions. This was equivalent to 4,550 million tons of coal, or an average of 1.6 tons for each individual of the population. Less than one-half (46 per cent.), was provided by coals and lignites, and 41 per cent. by petroleum and natural gas. It is interesting to compare the position in 1958 with that 20 years earlier in 1938. In 1958 world population was 30 per cent. more and world consumption of fuel and energy was 90 per cent. more than in 1938. Over this period, the quantity of coals and lignites used annually rose by 60 per cent., consumption of petroleum trebled, and the consumption of natural gas quadrupled. At the same time, the efficiency of utilisation of the fuels was increased. If world population and energy demand continued to increase at the same average geometric rate as during the last 20 years, then by the year 2000, or only 40 years from now, the population would reach about 5,000 millions and the annual energy demand would be equivalent to 17,500 million tons of coal; by the year 2100 the population would reach 18,500 millions and the annual energy demand would be equivalent to 435,000 million tons of coal.

Points and Pointers

COMMONWEALTH TECHNICAL TRAINING WEEK

The Duke of Edinburgh, in his capacity as President of the City and Guilds of London Institute, has approved the decision that in the United Kingdom the date of the Commonwealtn Technical Training Week will be from Monday, May 29th, 1961, to Sunday, June 4th, inclusive. It is hoped that it will be possible to hold the "Week" in otner parts of the Commonwealtn, and that, as far as possible, the same dates will be cnosen. In May, 1959, at a meeting at Buckingham Palace, it was agreed that such a Commonwealth Technical Training Week should be held throughout the Commonwealth in 1961. The object of the Week is to stimulate awareness of the responsibility of the community towards young people entering employment, and to stress the importance of schemes of induction and training. Tne City and Guilds of London Institute undertook central administrative responsibility for the Week. In this country, the direct organisation will be in the hands of local authorities. Tne Institute has, therefore, written to all county, city, borough, and urban and rural district councils in England and Wales, and to local authorities in Scotland and Northern Ireland, informing them of the date selected. Local authorities are also asked to consider whether they wish to take part in the Week, and, if so, to decide among themselves the most suitable areas for the purpose, and the best way of organising the Week so as to secure the most effective co-operation of the many interests concerned.

TEACHERS' COLLEGE

Sir Alexander Fleck, with the support of Sir David Eccles, Minister of Education, is appealing to industry to help in the establishment of a staff college for senior teachers in colleges of technology and commerce and senior industrial staff. He is asking industrial and commercial firms to contribute £100,000, and £60,000 has already been promised after private approaches to thirty firms. The running costs, amounting to about £30,000 a year, will be paid mainly from public funds. The college will provide a centre for the exchange of ideas and experience, and will thus benefit industry and commerce directly by giving their staffs a closer link with the technical colleges, and indirectly by improving the quality of the young men whom they will recruit in the future. The proposal to establish a staff college was included in the recommendations of the report of the Willis Jackson Committee on the Supply and Training of Teachers for Technical Colleges. The College is intended to be a small one offering a series of short courses of two to four weeks throughout the year, the first of which, it is hoped, would start before the end of 1961. The numbers attending each course would be kept low enough to permit each member to make a full contribution out of his own experience—probably not more than thirty. It is desirable that about two-thirds of these should be experienced teachers, the rest being a variety of people from associated fields—industrial education and training officers, personnel managers, works managers, research, production and sales staff, school and university staff, etc. Each course would be devoted to some different major topic of concern to the technical colleges, having to do with the development of teaching methods, the organisation of new courses, the emergence of new technologies, and the administration and organisation of the colleges. There would be no "instruction" in these subjects. The participants would come to pool their own ideas and experience and learn from one another. But there would have to be a nucleus of permanent staff. It is envisaged that the college would be a self-governing entity with its own governing body consisting of representatives of industry and commerce, of local education authorities and teachers. The permanent staff, headed by a director of studies, would run the college under the guidance of the governing body, who would be responsible for the buildings, the appointment of staff, the programme of courses, administration, finance and general policy.

NEW I.C.I. PLANT IN WEST OF ENGLAND

I.C.I. Limited has decided to commence building the first plants on the company's new one-thousand-acre site in south Gloucestershire, three miles north of Avonmouth. Construction work will begin during the next three months, and will be supervised by I.C.I.'s own staff. The plants are expected to start production in about two years' time. The first stage of construction on the site, which will be known as Severnside Works, will involve spending about £5 million on the initial site development and on the construction of plants for making 35,000 tons per annum of ethylene oxide, ethylene glycol and associated products. The main raw material, ethylene, will be supplied by Esso Petroleum Co. Ltd., from its refinery at Fawley, through a proposed 70-mile pipeline which, if approved by the appropriate authorities, will be the first of its kind in this country to link a refinery and a large chemical plant. It will cost approximately £800,000. The ethylene oxide will be made by the air oxidation process developed by Scientific Design Company, Inc., who will also design the plant, while the plants for ethylene glycol and associated products will be designed by I.C.I.'s own staff. The initial site development, and provision of services, will be in accordance with plans made since 1957, when I.C.I. first announced its long-term intension to develop a large chemical factory on Severnside. The general pattern of development of this works is expected to resemble in many respects that of I.C.I.'s Wilton Works in North Yorkshire, where more than £100 million has

been spent since 1949, and where investment in new plants still continues. The growth in the demand for ethylene, used principally in making "Alkathene" (I.C.I.'s brand of polythene) and ethylene glycol, which in turn is used in making "Terylene" polyester fibre, is continuing so strongly, that the output at Wilton is being expanded as quickly as possible in addition to the arrangement to draw supplies from Esso. When these plans come into effect, I.C.I.'s ethylene supplies in the U.K. will total 180,000 tons per annum, besides the substantial qualities made overseas by plants of subsidiary companies in Canada, Australia and India. There will be corresponding increases in the output of associated products at Wilton, including propylene and butadiene, and in the output of plants using these olefines.

INSTRUMENT, ELECTRONICS AND AUTOMATION EXHIBITION

Twice the size of its predecessors in conception, floor space and the number of exhibitors, the Third International Instruments, Electronics and Automation Exhibition is to be held at Olympia, London, from Monday, May 23rd, to Saturday, May 28th, 1960, inclusive. Nearly 500 firms (including 100 from overseas) will show a very comprehensive range of instruments and instrumentation equipment, which will be displayed on approximately 150,000-sq. ft. of stand space. H.R.H. the Duke of Edinburgh has consented to become Patron of the Exhibition. The group of industries sponsoring the Exhibition are represented by:—The British Electrical and Allied Manufacturers Association, the British Industrial Measuring and Control Apparatus Manufacturers Association, the British Lampblown Scientific Glassware Manufacturers Association, the Drawing Office Material Manufacturers and Dealers Association, the Electronic Engineering Association, and the Scientific Instrument Manufacturers Association of Great Britain. The Electronic Forum for Industry (EFFI), founded two years ago as a means of projecting to all users and potential users of electronic equipment the wide and varied scope of the electronics industry, is staging a three-day symposium during the Exhibition. Particulars can be had from the exhibition organisers. The symposium will be held in the Olympia Conference Hall on Wednesday, Thursday and Friday, May 25th, 26th, and 27th.

THE INSTITUTION OF ELECTRICAL ENGINEERS

The Council of the Institution of Electrical Engineers announce the election of an Honorary Member of the Institution, Colonel B. H. Leeson, C.B.E., T.D., in recognition of his outstanding contribution to the application of electrical science and engineering in the manufacture of electrical plant and associated equipment; and the development of co-operative effort within the electrical industry and to the training of electrical engineers, and of the services he has rendered to the Institution for more than 50 years. It will be remembered that Colonel Leeson recently retired as a director of BEAMA, and furthermore he was, in 1952, President on the Institution of Electrical Engineers. Normally, only one Honorary Member is elected each year, but once in every three-year period the Council is empowered to elect an additional Honorary Member. In this category it has elected Dr. Richard L. Hearn, M.A.Sc., D.Eng., for his notable contribution in the development of electrical generation and distribution, particularly in Canada, and for the part he has played in international co-operation in this field. Dr. Hearn has held a succession of appointments with the Hydro-Electric Power Commission of Ontario and served as Chairman of the Commission from 1955 to 1956. His name is associated with pioneering work in large-scale steam generating technique in Canada and exploiting power generation from Niagara Falls. He is now a director of Atomic Energy of Canada Ltd. The Council has also made the thirty-eighth award of the Faraday Medal to Sir George Thompson, D.Sc., F.R.S., in recognition of his outstanding contribution to the advancement of electrical science, and the leadership in research which he has given to others in this field, and to his inspiring services to education in science and technology.

SIZEWELL NUCLEAR POWER STATION

As mentioned briefly in our February issue, the Central Electricity Generating Board announced that the Minister of Power has given his consent to the building of a nuclear power station at Sizewell, Suffolk. With the initially planned output of 650-MW, which would be larger than that of any of the nuclear stations at present under construction, the Sizewell station will help to meet the rising demand for power in Suffolk, Norfolk and adjoining areas. But subsequently, the invitation to tender by The Central Electricity Generating Board states that the output should be 550-MW. This reduction of 100-MW may mean that the Board's plans for really large reactors are not so ambitious as was supposed. Furthermore, the reduction also means that the programme target figure of 5,000-6,000-MW of nuclear power by 1966-67 is still further away from realisation. The Sizewell site comprises just over 200 acres of land, none of which is considered to be of high agricultural value, while the area is sufficient to permit extension of the station if required in the future. In an area where unemployment is still a matter of concern, a labour force of 2,000 men will be needed for the building. When completed in 1965, a staff of about 400 will be required to operate the station. The development will provide an addition of about £150,000 to the rateable value of the area when the station is fully-operational. The East Suffolk County Council granted planning permission for the station in April, 1959, and has co-operated fully with the C.E.G.B. during the initial investigation and subsequent negotiations. Tenders are being sought forthwith from the consortia of companies engaged in nuclear power station construction work, and preparatory work will be carried out on local access road improvement. It will be recalled that the four nuclear power stations at present being built by the C.E.G.B. are:—Bradwell, Essex (300-MW); Berkeley, Gloucestershire (275-MW); Hinkley Point, Somerset (500-MW); and Trawsfynydd, Merionethshire (500-MW). The C.E.G.B. has received consent for a fifth station, at Dungeness, Kent (500-MW), and consent is being sought for a 1,000-MW station at Oldbury, Gloucestershire. The South of Scotland Electricity Board is, of course, building the 300-MW nuclear power station at Hunterston, near Ardrossan, Ayrshire.

Little Barford 'B' Power Station

LITTLE BARFORD "B" power station, operated by the Eastern Division of the Central Electricity Generating Board, has been constructed adjacent to the existing "A" station, on a site near St. Neots, Huntingdonshire, on the east bank of the River Great Ouse. The capacity of the new station is 120-MW, the main plant installed comprising two 60-MW turbo-alternator sets of C. A. Parsons & Co. Ltd. manufacture, and two pulverised-fuel-fired unit boilers, supplied by Foster Wheeler Limited.

Although possibly small by modern standards, and of conventional layout, the station incorporates a number of interesting design features. Perhaps the most important of these is the instrumentation and automatic boiler control system supplied by Evershed & Vignoles Limited, which is based on electronic techniques, and is the first system of this type to be incorporated in a C.E.G.B. power station. Complete remote control of both boiler units is effected from a single control room. Other features are the outdoor construction of the boilers; the main circulating-water system, which has been designed to allow each turbo-alternator set to operate as a self-contained unit with its own cooling-tower; and the dry ash and dust-handling installation.

All coal is delivered by rail, the existing coal-handling plant which was supplied by International Combustion Limited for the "A" station having been doubled in capacity, plus the addition of a wagon-tippler, gravity-bucket conveyor, and further belt conveyors. Drag-scrapers are used for stocking-out and reclaiming.

Boiler plant

Each of the Foster Wheeler boilers has a maximum evaporative capacity of 550,000 lb./hr. at a pressure of 950 lb./sq. in. at the superheater outlet, and a final steam temperature of 910 deg. F. They are of the single-drum, natural circulation water-tube type, with a water-cooled combustion chamber, having a two-stage horizontal, drainable and ventable convection-type superheater and fitted with a non-steaming economiser. An air-heater is also provided. The boilers are fired with pulverised-fuel, fed to intervane-type burners via two Foster Wheeler type ball mills and their associated coal-feeders, classifiers, exhausters and distributors. Oil-fired burners, supplied by Associated British Combustion Limited, together with their ancillary equipment, are provided for lighting-up purposes. The combustion chamber of each boiler is waterwall-cooled on the front, rear, roof and sides, and is also provided with a water-cooled dry bottom. All steam generation takes place within the tubes forming the combustion chamber, and this allows a non-steaming economiser to be provided without the use of any convection generating surface.

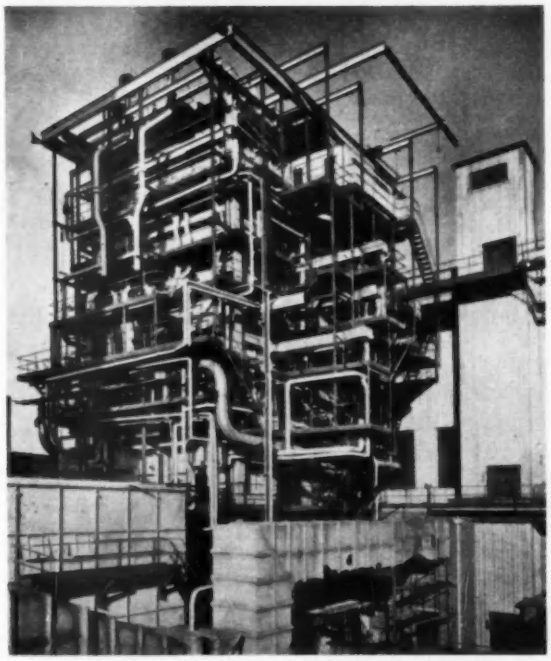
The superheater provided for each boiler is of the convection multi-looped type having primary and secondary sections with inlet, intermediate and outlet headers—the primary section being sited in the zone of the lower gas temperature, and the secondary section in the hotter zone immediately behind the slag screen. The primary inlet header, which receives the saturated steam from the drum, is the condenser control header for maintaining the desired steam temperature, and is provided with two tube-banks through which flows a controlled portion of the feedwater; this water by-passing the economiser. Positive control of the final steam temperature at 910 deg. F. from 440,000 lb./hr. evaporation to full-load, is ensured by means of this Foster Wheeler condenser-type of control, due to some of the steam entering the primary superheater tubes being condensed and having to be re-evaporated before superheating can take place. By varying the quantity of feedwater passing through the header condensers, and the amount of condensate so formed, which requires re-evaporation, the final steam temperature is controlled. This method of superheat control is completely automatic, avoids contamination of the steam, and only small quantities of by-passed feedwater are required.

The Premier Diamond steel tube cast-iron-protected economiser supplied for each boiler by E. Green & Son Ltd., Wakefield, is of the steaming type, with a heating surface of 23,328 sq. ft. and comprising 216 tubes arranged 18 tubes wide and 12 high in two shallow tiers with ample access space between. On m.c.r. load, the gases enter the economiser at 1,070 deg. F., and leave at 704 deg. F., the feedwater temperature being raised from 385 to 525 deg. F. The economiser heating surface is made up of steel tubes on which are shrunk cast-iron sleeves, giving a well-distributed straight-through gas flow, coupled with all-round accessibility. In accordance with modern power station practice, the economisers are of all-welded construction. Sootblowers have not been fitted, but facilities are provided for occasional off-load water-washing.

The air-heater fitted to each boiler has a heating surface of 192,000 sq. ft., and is of the tubular-type designed so that the gas and air flows are counter current. The tubes are arranged in three vertical passes, the gases flowing through the tubes with the air flow across them. In order to maintain the temperature of the cold end of the heater above the dew-point of the gases at low loads, the first four rows of these tubes at the air inlet end are screened-off from the remainder of the pass, and are connected direct to the gas space of the economiser outlet. Provision is made for off-load water washing, and a curtain damper, supplied by Metropolitan Engineering Co. Ltd., is provided in the gas duct between the air-heater and the electrostatic precipitators, to prevent excessive cooling of the back-end during shut-down periods.

The two Foster Wheeler double-ended p.f. ball-mills provided for each boiler are of the double-classifier-type, in which the coal and hot air enter at each end of the mill, and the pulverised fuel, in suspension, leaves at both ends of the mill. The mills always operate under suction conditions. Two classifiers of Foster Wheeler design are provided for each mill, these classifiers rejecting oversize particles of coal and ensuring that the coal-laden

air stream leaving the classifier carries only such coal as meets the fineness requirements. A by-pass damper is provided for use when it is desired to increase the amount of coal leaving the classifier, and when a reduction of coal fineness can be tolerated. Eight 30-in. intervane pulverised-fuel burners are fitted to each boiler, each burner having an oil-fired burner passing through its inner sleeve



for lighting-up purposes. Soot-blowing equipment supplied by Hopkinsons Limited, is fitted, while provision is also made for water-washing.

Two f.d. and two i.d. fans were supplied by Musgrave & Co. Ltd., for each boiler. The f.d. fans are vane-controlled, and are driven by single-speed, 3,300-V squirrel-cage motors rated at 225-h.p., while the i.d. fans are driven

Fig. 1 (above). One of the two outdoor boilers supplied by Foster Wheeler Limited.

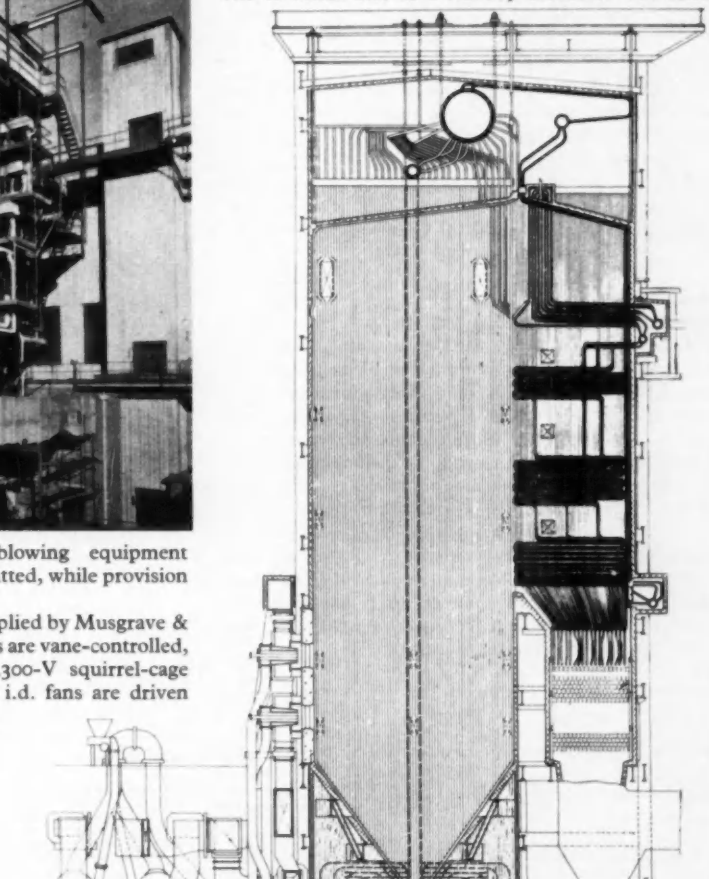


Fig. 2 (right). Cross sectional arrangement of one of the two boilers, each of which is rated at 550,000 lb./hr. at 950 lb./sq. in. and 910 deg. F.

through size 32 SCR.4 Vulcan-Sinclair fluid-couplings, which provide an infinitely variable speed regulation from 965-200 r.p.m. by similar motors rated at 400-h.p. The motors were supplied by Metropolitan-Vickers Electrical Co. Ltd. [now A.E.I. (Manchester) Ltd.] and the fluid-couplings by Fluidrive Engineering Co. Ltd.

The boilers are of out-door construction, a bitumastic water-proof coating having been used to protect all lagging and ducting exposed to the atmosphere. The major portion of the boiler drum is covered with similar water-proofing materials, but enclosures have been provided for the drum-ends and water-level detection equipment.

Ash and dust-handling plant

The ash- and dust-handling plant, supplied by John Thompson Industrial Constructions Limited, for each boiler, comprises a pneumatic suction system, both units operating from a common installation of three turbine-type, direct-coupled exhausters, each rated at 120-h.p., one of which acts as a standby machine. Provision has been made for crushing the furnace ash if necessary; both the ash and dust being drawn through 10-in. cast-iron pipe-lines to two 100-ton capacity storage containers. These containers are fitted with multi-tube ceramic filter heads, and provision is made for back-flushing. Road vehicles, which can be loaded at a rate of 25- or 50-ton/hr. from each container, through two rotary

valves and twin-screw dust-conditioners, transport the dust to a nearby tipping or disposal area.

Two Sturtevant Engineering Co. Ltd. electrostatic precipitators of the tubular-type are provided for each boiler, the total gas volume at m.c.r. for each pair of precipitators being 238,000-cu. ft./min. at 326 deg. F. The precipitator design is based on a maximum of 163 lb./min. of dust from each boiler, and an efficiency of collection of 97.5 per cent. at full load. Each precipitator is provided with a 75-kVA high-tension set, so arranged that when required, one high-tension set may be used to supply two precipitators. Remote and automatic control is fitted to the precipitator plants for both boilers.

Automatic boiler control

The fully-automatic control system for the two Foster Wheeler boilers was designed and supplied by Evershed & Vignoles Limited, and may be sub-divided into the following main groups:—(1) Master control of the rate of fuel input; (2) Mill-inlet suction control; (3) Mill-outlet mixture temperature control; (4) Combustion-chamber pressure control; (5) Air/steam-flow ratio control; (6) Steam temperature control.

Transmitters

The measuring elements for this scheme are all based on the principle of the Evershed electronic repeater (Fig. 3) which involves adjusting the electrical current flowing through a feed back coil until the force produced is equal to that due to the physical condition being measured. A number of different measuring elements are available, designed for varying conditions of pressure, temperature, flow, level, specific gravity, etc. The force produced by this element is applied to a beam (B), to the other end of which is fixed a coil (L), suspended in the field of a permanent magnet (M). The contact connected to the grid of the thermionic valve (V) is mounted on the beam and the two contacts (E & F), connected respectively to points of positive and negative bias, are mounted on the base of the transmitter.

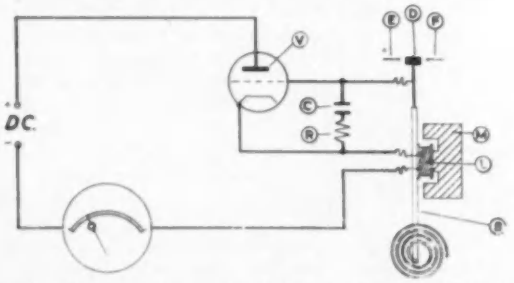


Fig. 3. Diagrammatic arrangement of the Evershed electronic repeater system.

Beam (B) also carries near its end, the disc contact (D), which lies between two fixed contacts (E and F). These contacts carry negative and positive bias voltages respectively. If, therefore, the force applied results in the deflection of the beam (B), the disc contact (D) will touch one of the biasing contacts and thereby apply the bias voltage to the grid of valve (V). The current through the valve (and through the coil and the receiver) will thus be altered until the torque exerted by the magnet and coil (L) (which is controlled by the current through the coil) balances the force applied to the beam, when disc contact (D) will break contact with (E or F). The balancing current thus established is proportional to the physical quantity measured. Resistor (R) and condenser (C), in the grid circuit of the thermionic valve, provide storage of the bias voltage when contact disc (D) returns to the neutral position. A gradual decline of the bias voltage will tend to re-establish contact between (D and E) or (F), which will re-set the bias voltage at the appropriate level.

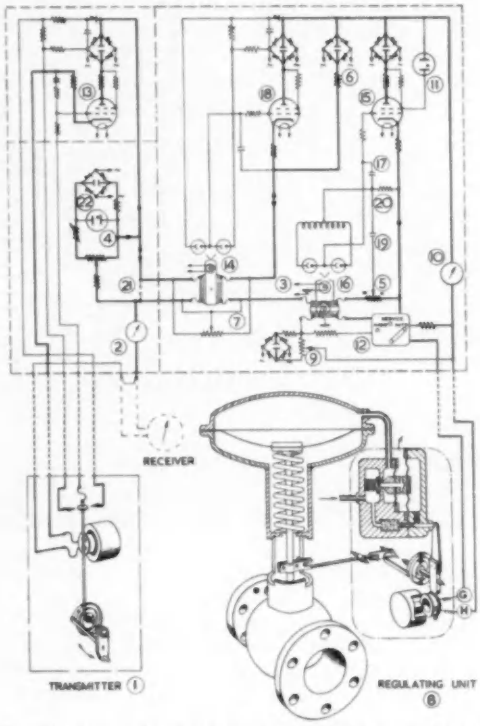


Fig. 4. Diagrammatic arrangement showing the controller circuit with external connections to the transmitter and regulating unit.

KEY:—(1) transmitter; (2) indicator; (3) variable resistor; (4) potentiometer; (5) resistor; (6) bridge rectifier; (7) differential shunt; (8) regulating unit; (9) hand-control knob; (10) current indicator; (12) auto/hand/service switch; (13) electronic tube; (14) photoelectric relay; (15) electronic tube; (16) photoelectric relay; (17) capacitor; (18) valve; (19) capacitor; (20) resistor; (21) terminals; (22) neon-stabilised voltage source; (G & H) controller output terminals.

In a number of cases the signals from several transmitters are applied to a simple beam-balance type computer, the output of which follows a predetermined law. An example of this is the computer for controlling the hydraulic coupling that regulates the output of the i.d. fan, and which receives a signal proportional to total fuel input to the mills, and another signal proportional to boiler combustion-chamber pressure. The computer output is then converted to an operating force at the coupling, by applying the current to the magnet of an oil-jet type hydraulic actuator, so that the requisite correction is applied to the i.d. fan drive speed via the hydraulic coupling.

Three-term electronic controllers

The output from the controller is proportional to the error, plus the integral and derivative of the error, and the three terms are non-interacting. The performance of the controller is not affected by variations in controller component characteristics. The controllers can be arranged for cascade operation as in the case of the steam temperature control system described below. Each controller consists of a Miniplaque which is mounted on the control panel and incorporates the proportional, integral and derivative settings, the measured value and controller output currents, the desired value and hand control settings, and the auto/manual changeover switch. The Miniplaque is connected by a 25-core cable to the electronic component trays, mounted in racks in a cubicle installed in a room just below the control room. These trays are all interchangeable, and when a fault occurs, the replacing of the trays for that controller enables it to be put back into full operation.

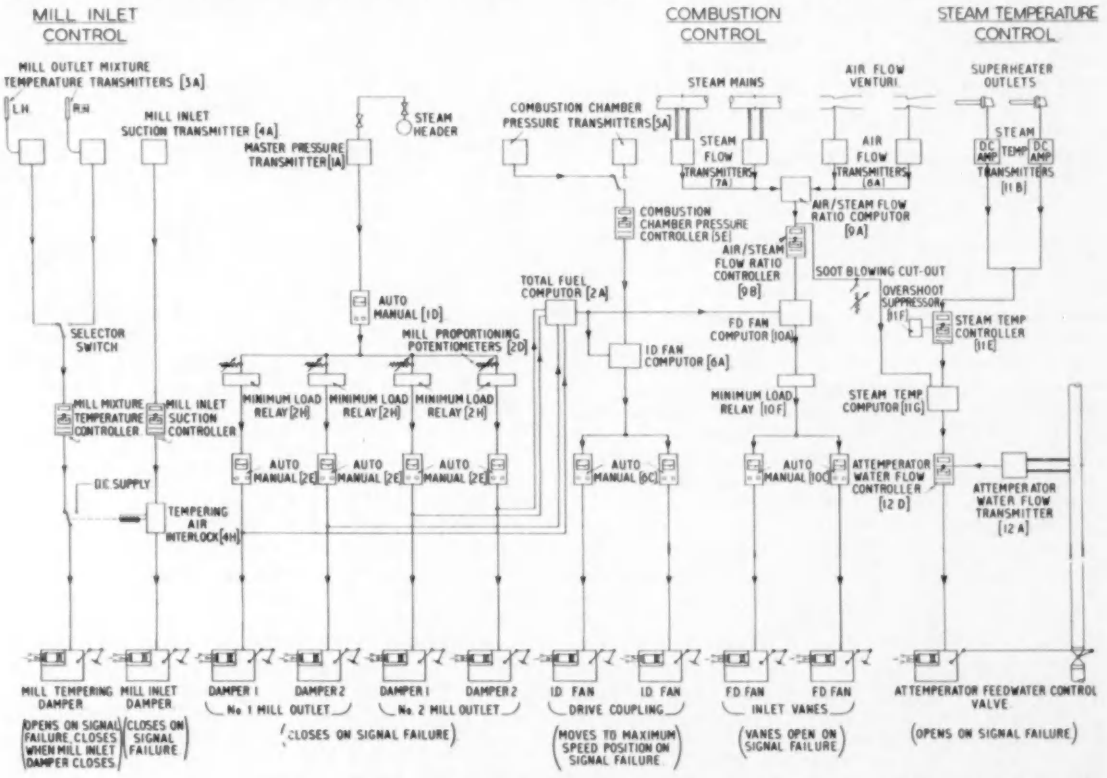


Fig. 5. Diagrammatic arrangement of the complete automatic control system as applied to the two boilers installed at the Little Barford "B" power station of the Central Electricity Generating Board.

Slave cylinders or positioners

Each damper or valve forming part of the automatic control system is operated by an electro-hydraulic positioner which received the current sent out from the appropriate auto/manual control station or Miniplaque over the range of 0-15 mA. Each positioner is self-contained with its own electric motor-driven control oil pump, and the case itself forms the sump for the control oil supply. The current referred to energises the coil of an electro-magnetic head which acts on one side of a hydraulic relay, on the other side of which acts a spring whose compression is adjusted by a cam in proportion to the position of the shaft and lever operating the damper. If the force due to the current does not equal that due to the feed-back spring, the hydraulic relay is deflected and causes the piston to move until the spring compression balances the current received from the control panel. A hydraulic lock has been provided which, on failure of the control oil pressure, prevents the positioner from moving. To operate the cylinder manually under these conditions, the hand/automatic valve has to be moved to the "hand" position and in so doing equalises the pressure across the cylinder and allows oil to pass from one side of the piston to the other. Each positioner is also provided with a pressure switch which causes a common alarm indication on the panel, and lights a lamp associated with the appropriate auto/manual station or Miniplaque.

Master control of fuel input rate

A diagrammatic arrangement of the complete control system is shown in Fig. 5. The master steam-pressure transmitter (1A) is provided, and arranged to send out a 0-30 mA signal for a steam-pressure change of 975 to 925 lb./sq. in.—the current falling with an increase in pressure. This current passes via the auto-manual

control station (1D) to the input circuit of the minimum load relays (2H), and then passes via auto/manual stations (2E) to the electro-hydraulic positioners operating the mill outlet dampers which regulate the rate of fuel input to the boiler. The minimum load relays (2H) are so arranged that their output current is approximately 15 per cent. greater than the input current, so that even if the latter falls to zero a residual current will be fed to the mill outlet dampers preventing them from closing completely. Potentiometers (2D) are provided, and arranged to vary the amount of shunting across the input coil of the appropriate minimum load relay to enable the relative loading of the mill outlet dampers to be adjusted. The mill outlet dampers are arranged so they close on control signal failure.

Mill inlet suction control

A diaphragm-type pressure transmitter (4A) has its diaphragm chamber connected to a tapping point in the mill suction duct, the output current from this transmitter being linear to inlet depression. This output current is passed to the input circuit of a three-term controller, the output from which is received by the electro-hydraulic positioner regulating the mill inlet damper until the mill inlet suction has the value set by the controller. The mill inlet damper positioner is arranged so that on failure of the control signal, the positioner will close the damper.

Mill outlet mixture temperature control

A temperature transmitter (3A) is provided in each of the two outlet ducts from each mill and arranged to send out a current of 0-30 mA proportional to the temperature in the duct. One of these currents is selected to pass to the input circuit of the mill mixture temperature controller, the output of which is fed via an electrical relay to the electro-hydraulic positioner regulating the tempering-air damper to maintain the mill mixture temperature at the required value. The electro-hydraulic positioner is arranged to open the damper on the failure of the control signal. An interlock has also been provided between the mill mixture damper and the appropriate mill inlet damper, so that whenever the latter closes, the tempering-air damper closes as well. A relay (4H) in the control line to the mill inlet positioner is set so that when the control current to the mill inlet damper falls to say 3 per cent., a contact is made which will energise the relay and allow 15 mA d.c. to be fed to the electro-hydraulic positioner operating the mill-tempering-air damper, and will close the damper.

Combustion chamber pressure control

Two diaphragm pressure transmitters (5A) are provided to measure depression in the furnace on the two sides of the boiler. One of the output currents from these transmitters is selected to pass to the input circuit of the combustion chamber pressure controller (5E), the output from which passes via the i.d. fan computer (6A) and auto/manual stations (6C) to the electro-hydraulic positioners regulating the couplings on the induced-draught fan. The i.d. fan computer also receives a signal from the total fuel computer (2A), the output from which is the sum of the currents sent to the electro-hydraulic positioners operating the four-mill-outlet dampers. As the rate of fuel input is roughly proportional to the opening of the mill outlet dampers, then this summated current is roughly proportional to the total rate of fuel flow. The equation for the i.d. fan computer is: Output $= \frac{M}{2} + 2C$. Where M is the output from the total fuel computer 0-30 mA., and C is the output from the combustion-chamber pressure controller 0-15 mA.

In operation the scoop-tubes of the induced-draught fan vanes will be positioned roughly in relation to the amount of fuel entering the boiler, this position then being trimmed by the combustion chamber pressure controller to restore the pressure to the required value. Thus, on a change in load, fuel and air flow will change together and there will be no delay between a change in heat input and the corresponding change in scoop-tube position to give the same furnace depression at the new load. The induced-draught fan drive coupling positioners are arranged so that on a failure of control signal the couplings move to maximum speed.

Steam/air ratio control system

Two steam-flow transmitters (7A) are provided, one for each of the steam outlet mains, and arranged to send out a current of 0-15 mA corresponding to a change in steam flow of 0 to 325,000-lb./hr. These two currents are summated electrically by connecting the positive and negative terminals in their output circuits, and this summated current passes to one coil of the air/stream flow ratio computer (9A), the other coil of which is receiving the output current from the two air-flow transmitters (8A) measuring air-flow in terms of differential across the venturi installed in the inlet ducts of the two f.d. fans. The air/steam ratio computer has the equation:—Output $= 15 \frac{A - K}{S}$ where A is the summated air flow current 0-30 mA., S is the summated steam flow current 0-30 mA., and K is a constant, fed from a d.c. source.

The output current from the air/steam flow ratio computer passes via the air/steam flow ratio controller (9B) to the f.d. fan computer (10A), and the minimum load relay (10F) and then via the auto/manual stations (10C) to the electro-hydraulic positioners regulating the inlet vanes of the f.d. fans to maintain the air/steam ratio at the value set by the controller. The f.d. fan computer also receives the output current from the total fuel computer in a similar manner to the i.d. fan computer, and has a similar equation. When the load changes, the output current sent out by the total fuel computer roughly positions the f.d. fan vanes according to the new rate of heat input; this position then being trimmed by the air/steam ratio control so as to restore the ratio to the required value at the new load. The minimum load relay is arranged so that it sends out a current which is up to 10 mA below the input current, so that since the f.d. fan vanes open on a failure in control current, the vanes can never close below a pre-determined amount, thus preventing extinction of the furnace flame.

Steam temperature control

Two steam temperature transmitters (11B) are provided, each connected to a thermocouple installed in the two outlet steam mains from the boiler. The currents

sent out by these transmitters are linear to temperature, and are summated electrically and passed to the input circuit of the steam temperature controller (11E) which will function with proportional plus integral plus derivative action. In order to suppress any tendency to overshoot when coming up to load, the controller is provided with an integral limiting relay (11F) which will ensure that the integral term of the controller does not become saturated even when an error has existed for a period of time, as will be the case if the boiler has been running at low loads for a period. The output current from the steam temperature controller passes to one coil of the steam temperature computer (11G), the other coil of

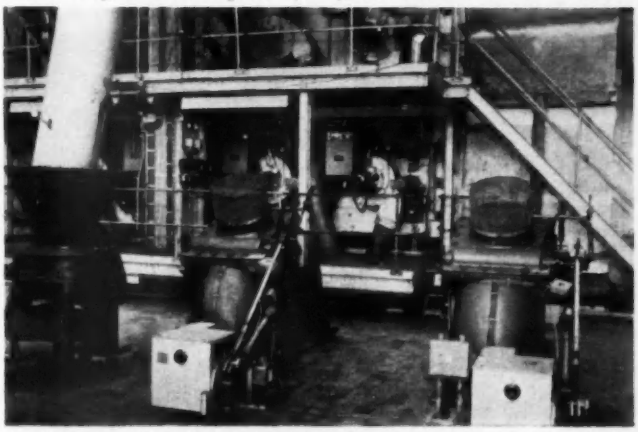


Fig. 6 (above). Part of the boiler firing aisle. Two of the Evershed electro-hydraulic positioners incorporated in the mill control system can be seen in the foreground.

Fig. 7 (right). Complete remote control of both boilers is effected from a single control room.

which is receiving the output from the air/steam flow ratio computer. The output from the steam temperature computer is equal to the arithmetical sum of these two currents, and the equation of the computer is :- Output = T × (A-15), where T is the output from the steam temperature controller 0-15 mA. A is the output from the air/steam flow ratio computer 0-30 mA.

The output current from the steam temperature computer is received by the attemperator water-flow controller (12D), the reset terminals of which are receiving the output current from the attemperator water flow transmitter (12A). The output from this controller is passed to the electro-hydraulic positioner regulating the opening of the attemperator feed-water control valve. The desired value of the attemperator water-flow controller is determined by the value of the signals sent out by the steam temperature computer, and the valve is adjusted by the attemperator water-flow controller until the water-flow determined by the value of this signal is obtained.

Any change in boiler load causes the current from the air/steam ratio computer to fall, and (through the steam temperature computer) to call for an increase in attemperator water-flow. After a short delay, the steam temperature starts to rise slightly and the steam temperature controller output also calls for an increase in attemperator water-flow, but the air-steam ratio will, during this period, tend to be restored to its previous value under the action of the air/steam ratio controller. The settings of the steam temperature controller and the steam temperature computer are such that as the output from the air/steam ratio computer reverts to its normal figure, the output from the steam temperature controller rises, so that the attemperator water flow remains at the increased value demanded by the change in air/steam ratio.

To prevent undesirable fluctuations in the steam temperature control during soot-blowing, a soot-blowing cut-out relay is incorporated in the output circuit between the air/steam flow ratio computer and the steam temperature computer. Normally, this cut-out will be out of action and the full air/steam flow ratio current will be passed to the steam temperature computer. During soot-blowing, however, this switch will be moved to the "out" position when the corresponding coil of the steam temperature computer will be short-circuited. If the soot-blowing cut-out is turned at a suitable speed, no sudden movement to the feedwater value will be produced, nor should there be any disturbance of the steam/air flow ratio control system.

Turbo-alternator plant

The two 60-MW turbo-alternator sets supplied by C. A. Parsons & Co. Ltd. are each designed to operate

with steam conditions of 900-lb./sq. in. and 900 deg. F. The alternators are cooled by hydrogen at 15 lb./sq. in. pressure, and the generated voltage of 11.8-kV is stepped up to 132-kV by generator transformers. The turbines are of the two-cylinder impulse-reaction type, the associated condensers each having a cooling surface of 60,000-sq. ft., and being supplied with 40,000-gal./min. of cooling water at 65 deg. F. They are designed to maintain a vacuum of 1.3-in. Hg. abs.

The main circulating-water system has been arranged to allow each turbine to operate as a self-contained unit, with its own cooling-tower—a design which has permitted the elimination of valves in the main c.w. pipelines. The condensers are each divided into two sections on the water side, and each section is fed by a variable-pitch axial-flow pump. A common suction-pit is provided for both pumps, but the discharges remain separate up to the irrigation level in the individual cooling-towers.

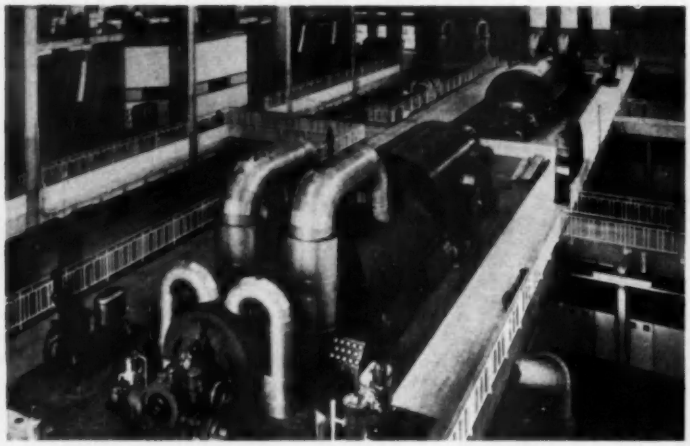


Fig. 8 (above). The two 60-MW turbo-alternator sets were supplied by C. A. Parsons & Co. Ltd. Each is designed to operate with steam conditions of 900 lb./sq. in. and 900 deg. F.

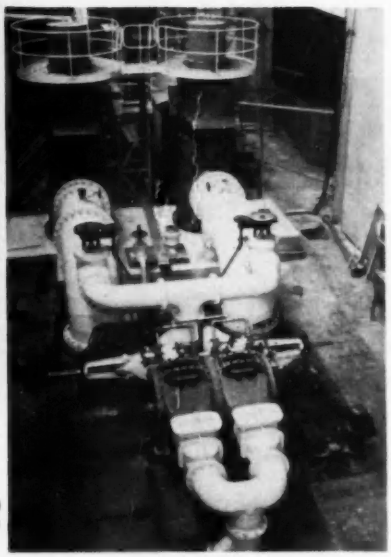


Fig. 9 (right). The c.w. pumps manufactured by Vickers-Armstrongs (Engineers) Ltd. are capable of providing a variable output in accordance with changes in the pitch of the impeller blades.

These pumps were supplied by Vickers-Armstrongs (Engineers) Limited, each pump being designed for an output of 22,000-gal./min. at a head of 60-ft., and driven at a speed of 585 r.p.m. by a drip-proof, squirrel-cage induction motor rated at 430-h.p. The pumps are capable of providing a variable output in accordance with changes in the pitch of the impeller blades. Output is varied while the pumps are in operation, the method of automatic control having been developed in conjunction with Evershed & Vignoles Limited. Briefly, the method consists of a vacuum transmitter connected to a point on the condenser shell, which passes a signal to a vacuum indicator and to the input circuit of an Evershed three-term electronic controller. A signal from the controller is then passed through manual control stations to the positioners of the servo motors operating the variable-blade displacement device of the pumps. The servo motors are mounted on the top of each pump main driving motor, together with an Evershed hydraulic-relay, electro-magnetic head servo piston and linkages. A manually-operated control is also provided for use in an emergency.

The Evershed electronic controls operate in the manner described earlier in this article, under the heading "Automatic boiler control system." By this means, any condition which arises in the condenser, such as fluctuations in turbine load, or the temperature of the cooling water, is automatically adjusted by varying the pump output in order to maintain the correct vacuum in the condenser. The advantage of the variable-pitch pump in this application is that no complicated method of speed variation is required, the pump efficiency being maintained over a wide range of flow conditions.

The cooling-towers associated with the c.w. systems each have a capacity of 2,550,000-gal./hr. They are of the natural-draught type, constructed of reinforced-concrete by Yorkshire Hennebique Contracting Co. Ltd.

The feedwater heating system is designed to raise the temperature of the feedwater to 385 deg. F., and is supplied with bled steam from the turbine at five points. Each boiler is served by two 650,000-lb./hr. capacity Spiroglide feed pumps, manufactured by The Harland Engineering Co. Ltd., and driven at 2,970 r.p.m. by 1,350-h.p. Harland electric motors. Evaporators are not provided, the water for boiler make-up being obtained from Tempsford, some three miles from the station site, and treated in a "Deminrolit" plant supplied by The Permutit Co. Ltd. A chlorination plant, manufactured by Wallace & Tiernan Limited, is also installed.

The Permutit water-treatment plant comprises a Hydrogen Ion "Starvation" unit, de-gasser and two mixed-bed "Deminrolit" units, together with ancillary equipment, instruments and controls. The plant is semi-automatic in operation and delivers 5,000 gal./hr. of purified water to the station's condensate return tanks. Raw water is first passed through the H.I. unit where the bi-carbonate alkalinity of the water is removed; CO_2 being released

in the process. The water then flows through a de-gassing tower against an upcurrent of blown air, the excess air picking up the CO_2 and venting it to atmosphere from the top of the tower. Meanwhile, the de-gassed water collects in a sump below the tower, from which point it is circulated to the " Deminrolit " units. These are arranged in parallel, and subject the semi-treated water to an infinite number of alternating cation and anion exchanges, the resultant effluent being a silica free, demineralised water of very low specific conductivity. Concentrated chemicals for regeneration are held in bulk storage tanks adjacent to the plant. Vacuum-operated measuring vessels draw a measured quantity of each chemical from these tanks and pass them to dilution tanks in preparation for hydraulic injection into the H.I. and " Deminrolit " units when required. The H.I. unit is regenerated with diluted sulphuric acid and the " Deminrolit " units firstly with dilute caustic soda solution (for the anion exchange resin) and secondly with diluted sulphuric acid (for the cation exchange resin). In the case of the " Deminrolit " units the resins are separated, into two layers, before regeneration by an upflow of water and re-mixed afterwards by a stream of blown air.

Both the high-pressure and the low-pressure pipework was supplied and installed by Stewarts & Lloyds Limited.

Coal Blockages Eliminated by Aluminium Chutes

The appearance of pieces of scrap aluminium in some industrial coal supplies during the war, probably due to railway wagons not having been properly emptied after the conveyance of scrap aircraft material, has indirectly led to the present increasing use of aluminium in the fabrication of coal chutes. In coal-fired steam raising plants, steel chutes are frequently subject to rapid deterioration caused by the combined action of corrosion and erosion, with the result that the life of the chutes may vary between 2½ and 5 years. Steel chutes of riveted or even welded construction also often have the disadvantage that they may be subject to frequent blockages due to the coal having to pass over rough interior surfaces. With the very wide use of pulverised-fuel-fired boilers, such blockages, which interfere with the fuel supply, may cause loss of ignition which could result in damage to the refractories, and, of course, loss of output. At the Cowes (Isle of Wight) electricity generating station, it was noted that even after being buried within coal stocks for quite long periods, certain aluminium alloys remained remarkably free from corrosion. This observation led the then station superintendent at Cowes to carry out experiments in order to determine the benefits (as regards both maintenance and cost) to be derived from the use of aluminium for coal chutes. In 1949, an experimental aluminium alloy section (Noral 65ST supplied by Northern Aluminium Co. Ltd.), of riveted construction, was incorporated in a new steel coal chute, and examined annually over a period of five years. The steel sections were replaced in 1954, but the aluminium section remained in service and continued to provide much valuable information for subsequent applications of a similar nature. Between 1949 and 1954 the aluminium section showed a total weight loss through erosion of 5-lb., or about 8½ per cent. A significant development during the experiments was that the flow of " green " coal through the chute caused the interior surface of the aluminium section to take on a mirror-like finish as compared with the rough surface of the steel sections of the chute. This feature led to similar experiments being carried out at the Central Electricity Generating Board's generation station at Earley, nr. Reading, and where frequent blockages in coal chutes of steel construction, and conveying coal to the pulverising mills caused output losses, together with the attendant difficulties associated with re-ignition. To solve this problem, an experimental aluminium chute, designed in conjunction with Northern Aluminium Co. Ltd., was fabricated by a local firm, using ¼-in. thick Noral B54SM (B.S. NP5/6M) alloy plate in an all-welded construction. The chute was installed in September, 1953, and the experiment proved successful, resulting in the subsequent replacement of the remaining 13 steel chutes in the boiler house at the station with chutes and also hoppers of aluminium construction. The first chute has now been in service for some 28,300 hours, and has conveyed more than 60,000 tons of coal from the bunkers to the pulverising mills. It has already outlived its steel counterparts without showing any appreciable signs of wear, and it is estimated that its life will be at least double that of a steel chute. As regards cost, the aluminium chute is about equal to a similar one made from mild-steel but, as experience has already shown, its advantages in service far outweigh any cost considerations.

Aluminium coal chutes and hoppers supplied by Northern Aluminium Co. Ltd. and installed at the Earley power station, near Reading.

As stated in the November, 1959 issue of this journal, **Newton Chambers and Co. Ltd.,** Sheffield, have recently entered into a Licence Agreement with **Corner Tube Boiler Co. Ltd.,** for the production and sale of Corner Tube Boilers in Great Britain. This agreement covers the supply and installation of Corner Tube Boilers of up to 5,000-lb./hr. evaporation, and fitted with any type of fuel burner, and Corner Tube Boilers for duties up to 10,000-lb./hr. evaporation, or for hot water up to 10,000,000 B.Th.U./hr. capacity, when fitted with " Emma " stokers, and where additionally required with other types of fuel burners for the use of alternative fuels. It is not, however, an exclusive agreement for any size except for coke-fired boilers using the " Emma " firing system. **Babcock and Wilcox Limited** can supply either steam or hot-water Corner Tube Boilers of any capacity except where " Emma " stokers are required, and the other licensees, J. Hickey and Sons (C.T. Boilers) Limited, will continue to supply Corner Tube steam boilers up to 15,000-lb./hr. evaporation except in those cases where " Emma " stokers are preferred, and for which Newton Chambers and Co. Ltd. are the sole licensees in Great Britain, of the Patentees, Bronswerk N.V., Holland. The Corner Tube Boiler is of unique design, relying upon the heavy downcomers at its corners to support the tube-banks, and thereby dispensing with the need for an external skeleton of structural steelwork. The unit is suitable for working at high pressures. The " Emma " stoker is specially-designed for the most efficient use of solid fuels, and is particularly suitable for burning all types and sizes of coke.

* * *

Mr. G. M. Wells, sales director, has been appointed assistant managing director of Hopkinsons Limited, and **Mr. J. A. Fuller** has been appointed chief engineer of the company in succession to **Mr. G. Sewell** (director) who retired recently.

The Use of Refractory Concretes in Steam Generating Plant

ALTHOUGH refractory concretes, or castable refractories, as they are sometimes called, have been available for many years, it is only recently that a considerable increase in the general use of these materials in boiler and steam generating plants has become evident. The present demand for ever-increasing steaming rates with its associated problems of maintenance and efficiency has no doubt influenced boiler plant engineers in investigating different materials. It is, of course, well known that the weakness of normal refractory brick construction lies in the joints, the breakdown of which can allow leakage of air causing reduction in boiler efficiency. Refractory concrete, or castable refractories, give to boiler maintenance engineers the advantages and facilities of monolithic concrete construction; they are extremely adaptable and do not require the use of skilled labour in placing. Economically, they would give a saving in normal bricklayers' time, and have the added advantage that special shapes can either be cast in-situ, or made up of pre-cast units, thus eliminating the cutting and fitting of the brickwork. Until the last few years the term "refractory concrete" was normally associated with a mixture of aluminous cement and a crushed firebrick aggregate which has a service temperature limit of approximately 1,350 deg. C. The recent demand, however, for refractory concretes capable of resisting much higher temperatures has resulted in the development of "Secar 250," a white, pure, calcium aluminate cement, having less than 1 per cent. impurities (silica and iron oxides) and which is, therefore, much more refractory than the normal aluminous cement. The refractoriness of "Secar 250" mixes depends, of course, on the type of aggregate used, but when employed in conjunction with a fused alumina aggregate, it has a maximum service temperature limit of approximately 1,800 deg. C. A comparison showing the chemical analysis of the two cements is given in Table I.

TABLE I

Percentage of	High-alumina cement (Ciment Fondu)	Pure tri-calcium penta-aluminate cement ("Secar 250")
Al_2O_3	40.0	71.5
CaO	37.5	27.5
Fe_2O_3	9.0	<1.0
FeO	7.0	
SiO_2	4.5	
TiO_2	2.0	

Both are calcium aluminate cements, the normal aluminous cement (Ciment Fondu or Lightning in this country) being frequently referred to as high-alumina cement or calcium aluminate cement, while the pure calcium aluminate cement is sometimes referred to as tricalcium penta-aluminate cement. For the sake of clarity they will hereafter be referred to as Ciment Fondu and "Secar 250" respectively. They have similar physical characteristics and are stable under load up to their melting-points—hence their refractory properties. Hydrated Portland cement contains free lime, and when heated, decomposes with the liberation of more free lime and is, therefore, not recommended for use above 250 deg. C. Calcium aluminate cements contain no free lime, and liberate on hydration an aluminous gel structure which confers on the cements chemical resistant properties to dilute acids such as are present in flue gases and, for this reason, are used in flue and chimney linings.

Expansion characteristics

The expansion characteristics of refractory concrete are different from those of normal firebrick in that when they are first put into service and taken up to operating temperature, moisture is driven-off causing shrinkage which is counterbalanced by the inherent expansion of the aggregate with the result that the dimensions at operating temperature are, for all practical purposes, the same as the cold unfired dimensions. This is illustrated in the curve *AB* of the graph in Fig. 1. On cooling,

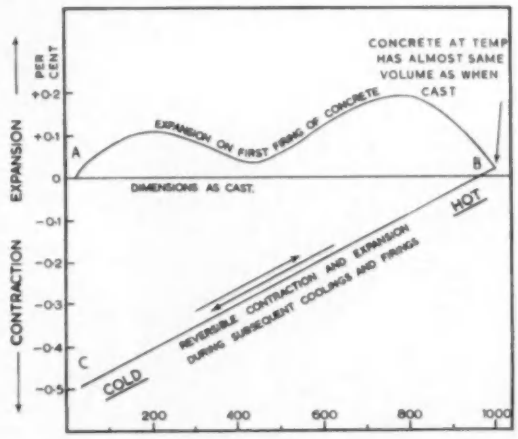


Fig. 1. Curves showing volume changes in refractory concrete when put into operation.

thermal contraction occurs and further heating and cooling cycles cause reversible expansion along the line *BC*. This means that in normal practice expansion joints are unnecessary, the provision of butt-joints being sufficient. In concretes made with "Secar 250" operating at temperatures above 1,300 deg. C., however, the inherent thermal expansion of the aggregate is sometimes greater than the shrinkage of the cement bond, and very thin expansion joints may therefore be advisable.

Refractory concretes are extremely rapid hardening and are ready for use in most applications in 24 hours since they do not normally require pre-firing before putting into service. They are extremely resistant to thermal shock; their very low spalling tendencies

being probably due to the nature of the micro-porous structure of the alumina gel cement bond, rendering them capable of resisting excessive and rapid fluctuations of temperature.

Strength characteristics

The effect of temperature on strength(1) of probably the most commonly used mix of Ciment Fondu/crushed firebrick is illustrated in Fig. 2. The cold strength is partially lost as the temperature increases, due to the dehydration of the hydraulic bond. At a temperature

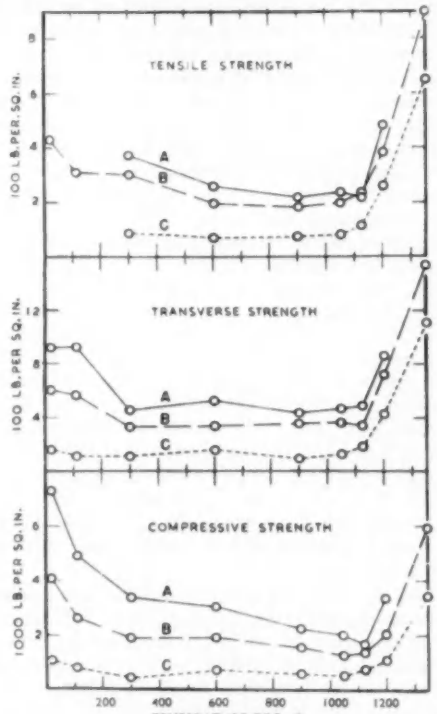


Fig. 2. Curves showing comparison of the strengths of refractory concrete (high-alumina cement/crushed firebrick) containing differing percentages of h.a. cement, after the following treatments: 24-hr. at 20 deg. C., 24-hr. at 110 deg. C., 4 months at 300 deg. C., 4 months at 600 deg. C., 5-hr. at all higher temperatures indicated— (A) 30 per cent. cement, (B) 20 per cent., (C) 10 per cent.

of approximately 1,100 deg. C. and over, a ceramic bond is formed, which increases both with time and temperature, and a fired strength is obtained which may be even greater than the original high cold strength.

This type of curve is applicable to all types of refractory concrete although variations do occur, according to the type of cement employed, and the refractoriness and type of aggregate. For instance, if a fused alumina aggregate is used instead of crushed firebrick, a higher strength may be obtained in the cold and at temperatures up to 1,100 deg. C., due to the inherent strength of the fused alumina. On the other hand, however, the increased refractoriness of the fused alumina would delay the onset of the ceramic bond until temperatures much higher than 1,100 deg. C. were reached. Similarly, if a "Secar 250" crushed firebrick mix were used, similar strengths would be expected up to 1,100 deg. C. to those obtained with the Ciment Fondu corresponding mix, but the greater refractoriness of the "Secar 250" would delay the formation of the ceramic bond until a temperature of approximately 1,300 to 1,400 deg. C. was reached.

It is apparent from the curves shown that for installations operating at temperatures well below the service temperature limit of the mix employed, and where strength and abrasion resistance are prime considerations, it is advantageous to use a concrete with a relatively high cement content. It should be remembered, however, that in mixes containing an aggregate which is more refractory than the cement, e.g., Ciment Fondu/crushed firebrick, the service temperature limit of the refractory concrete tends to decrease with the greater cement content —but this, of course, does not always apply to "Secar 250" since this material may be more refractory than the aggregate employed.

Resistance to abrasion

Where resistance to abrasion is important, it may be of interest to mention that a new abrasive resistant aggregate called ALAG has recently been marketed which has been produced solely for use with aluminous cements to give a heat-resistant concrete of very high strength (see Table No. 2) and abrasive resistant properties, and which is heat-resistant up to 1,200 deg. C. and has a better resistance to thermal shock than normal refractory concrete. Because of its high strength and enhanced abrasion resistant properties, it should be particularly suitable for the linings of ash pits, hoppers, etc. A suitable mix for a cast lining is 1 vol. Ciment Fondu: 2 vols. ALAG $\frac{3}{16}$-in. to dust: 2 vols. ALAG $\frac{1}{2}$-in.-$\frac{3}{16}$-in., whilst a suitable mix for application by cement-gun would be 1 vol. Ciment Fondu : $2\frac{1}{2}$ vols. ALAG $\frac{3}{16}$-in. to dust.

TABLE II

Comparison of the strength of Ciment Fondu concretes made with ALAG and with crushed firebrick aggregate after firing at various temperatures.
Mix: 1 vol. Ciment Fondu
2 vols. Aggregate ($\frac{1}{16}$ in. to dust)
2 vols. Aggregate ($\frac{1}{2}$ in. to $\frac{1}{16}$ in.)
i.e. approx. 7 cwt. Ciment Fondu per cu. yd. of concrete.

	Compressive Strength lb./sq. in.	
	Ciment Fondu/ ALAG	Ciment Fondu/ crushed firebrick
Unfired—1 day old	13,000	5,600
After firing at 600° C.	5,900	2,600
" " " 800° "	4,200	2,000
" " " 1,000° "	3,000	1,600
" " " 1,100° "	2,400	1,500
" " " 1,200° "	3,800	2,800

TABLE III

Aggregate	Fired density	Thermal Conductivity B.Th.Us./sq. ft./ hr./deg. F./sq. in.	Service Temperatures	
			With Ciment Fondu	With Secar
			°C.	°C.
Vermiculite ...	35	1.2	850-1000	
Diatomite ...	55	1.7	850-1000	
Crushed H.T. insulating brick	85	3.2	1350	1500
Expanded clay ...	90	3.5	1100	
Crushed firebrick	115	6	1350	1450-1530
Molochite ...	120	8		1500
Sillimanite ...	135	10		1600-1650
Carborundum ...	145	50		1650
Calcined low-iron bauxite ...	160	12		1650
Chrome-magnesite ...	165	8		1650
Fused alumina ...	175	16		1800
Bubble alumina	95	6		1700

Thermal properties

The thermal conductivity of a refractory concrete is usually less than the corresponding value of the aggregate from which it is made, except in the case of lightweight aggregates, and when made with dense refractory aggregate it is usually about three quarters of the value of the aggregate itself. These values are for all practical purposes independent of the type of cement and typical examples are given in Table 3. Lightweight aggregates such as vermiculite, diatomite, foamed slag and crushed insulating brick are employed for insulating concretes where the primary consideration is heat conservation, but they are not as strong or resistant to abrasion as concretes made with the denser refractory aggregates, and are therefore more often used as a backing.

Resistance to slag and reducing conditions

The slag resistance of a refractory concrete is obviously dependent to a large extent on the choice of aggregate, and where highly basic slags are encountered, a chrome, chrome-magnesite or magnesite aggregate is employed with either type of cement dependent on conditions. Where iron-free aggregates such as sillimanite, fused magnesia, and fused alumina are used, "Secar 250" should, of course, be employed. Mixes of "Secar 250" and fused alumina are in fact often used, since they have excellent resistance to both acid and basic slags. Although silicon carbide may be used as a slag resistant aggregate in refractory concretes, the cement bond cannot normally be expected to affect to any great extent the tendency of these materials to age or oxidise at high temperatures.

At relatively low temperatures (450-500 deg. C.) carbon monoxide reacts with iron compounds in refractory materials, for example firebricks, and may eventually cause disruption. Consequently, refractory concretes used in furnace atmospheres containing appreciable quantities of carbon monoxide should consist of "Secar 250" and iron-free refractory aggregates. Such conditions would, in general, be exceptional in boiler combustion chambers, but may sometimes occur in waste-heat boilers.

Installation

If the best results are to be obtained with castable refractories, it is essential that the basic principles of making ordinary concrete should be followed. For instance, the maximum size of the aggregate is governed to some extent by the minimum thickness of the concrete being placed. Similarly, the aggregate should be evenly graded throughout the size range and the amount of fine material passing the B.S. 100 sieve should not exceed about 10-15 per cent. Aggregate with a deficiency of fine material is equally undesirable, since the mix tends to be harsh with poor water-retention properties, giving rise to compaction difficulties and a tendency to bleed. Recommended mixes employing crushed firebrick are given in Table III. Most of the other refractory aggregates are not available in the larger sizes, and typical mixes are 1 vol. cement : 3-4 vols. aggregate $\frac{3}{8}$ in. to dust and 1 vol. cement : 2-3 vols. aggregate $\frac{1}{8}$ in. to dust.

Apart from the main exception of silica brick, a variety of refractory or semi-refractory materials may be employed as aggregates. They should, however, be free from impurities such as slags or jointing materials, and the mixer and tools should be free from any Portland cement, lime or plaster which may chemically affect the hardening properties of the cement. It is often more convenient therefore to use one of the various proprietary castables which consist essentially of suitably graded aggregate mixed with the correct amount of cement and merely require the addition of water. Castable premixes of this type are distributed by many reputable refractory manufacturers.

Most of the commonly used refractory and insulating aggregates are, of course, porous and, therefore, require pre-soaking if the best results are to be achieved. Water should be added with the aggregates, and mixed either mechanically or by hand until the initial suction is satisfied; usually about 4-5 minutes in a mixer is sufficient. Any excess water should then be drained off and the cement mixed with the soaked aggregate. More water may be added to bring the mix to the correct consistency, which should not be too sloppy.

Although normal compaction by hand is adequate for many applications, a denser concrete of better quality is obtained when vibratory compaction is employed, e.g., by poker vibrator, or attaching vibrators to the metal formwork for in-situ work, or by using vibrating tables for precast units. In fact this method of compaction should always be used whenever possible. The use of vibratory compaction means that less water is needed, and the workability of the mix should be suitably adjusted. A mix which has the correct workability for hand-compaction usually contains too much water for efficient vibratory compaction. It is not possible to specify the exact amount of water required since this varies according to the mix proportion and the grading and porosity of the aggregate employed.

"Bleeding" from joints in formwork or moulds should be prevented, and any porous material on which the wet mix is placed should be given either a preliminary soaking, or oiling, or covered with waterproof paper. After the mix has hardened, all exposed surfaces should be kept cool and wet for a further 24 hours if maximum strength is to be obtained. In many cases of emergency, however, satisfactory results are obtained when concrete is put into service only a few hours after placing. For instance, emergency gunning repairs have been effected on hot refractory at 1,000 deg. C. Refractory concrete may be put into service immediately after the curing period and the first firing should preferably be fairly slow in order to drive the water off gradually, but this is, of course, not necessary with subsequent heating and cooling cycles.

The rapid deterioration of the strength characteristics of steel above 400 deg. C. frequently restricts its use as heavy reinforcing in refractory concretes. It can, however, be used when positioned where this temperature is not exceeded, and in this case the allowance for the differential expansion between the steel and the concrete should be made. This is achieved by simply coating the steel with a bitumastic material. Wire mesh or expanded metal reinforcement has proved satisfactory in many applications, and practice indicates that it may be placed in zones at somewhat higher temperatures than normal heavy reinforcement, probably due to its less rigid

nature. For instance, in lining steel ducting (e.g. flues) and also chimneys with a refractory mortar by the gunite process, bolts are attached to the steel casing at roughly 12-18 in. centres approximately 1-2 in. long, extending about halfway into the lining and wire mesh spot welded on to them and the refractory cement mortar gunited on. Similarly, for shooting refractory cement mortars on to old concrete or brickwork, the mesh should be securely pegged or dowelled into position after taking the necessary precautions, to ensure that the old work is thoroughly cleaned, hacked and any suction damped out before guniting.

Walls are normally cast in-situ in alternate sections about 2-3 ft. square chequer board fashion, and after these have hardened, the subsequent sections are cast directly against them to form butt-joints. Anchoring hooks are frequently recommended, one end of which is embedded in the concrete at a minimum of 2-3 in. from the hot face, the other end being embedded in a common brick wall behind or fixed to the outer steel-casing.

Although there are several methods of constructing a flat arch, the one employing arch-hangers is usually

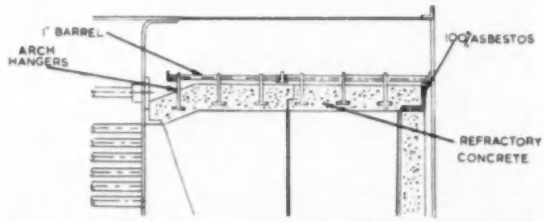


Fig. 3. Schematic arrangement showing the flat arch at the rear end of a Super Economic boiler employing arch-hangers.

preferred in boiler construction and is generally recommended. Fig. 3 shows the flat arch at the rear end of a Super Economic boiler which has been installed using this method. The arch hangers can be fabricated from ½ in. mild-steel rod with a 3 in. or 4 in. square plate fixed to the bottom and should extend to a minimum of from 2-3 in. from the hot face of the concrete. They are pitched at 15-18 in. centres and are usually supported from about a 1 in. barrel. The refractory concrete is poured on to horizontal shuttering of either wood or metal which should be well greased or covered with waterproof paper. The thickness of the arch is usually about 7-9 in.

Sprung arches can be quite simply constructed by casting the refractory concrete on to suitably-shaped wood or metal shuttering (greased or covered with waterproof paper) in about 3 ft. sections, a minimum rise of 2 in. per foot of span being desirable. Naturally, there is no necessity for any reinforcement with a normal "sprung" arch.

Shell-type boilers

Stationary locomotive boilers, like many vertical boilers, do not require any elaborate foundations but in the case of the larger shell-type boilers, they usually take the form of a concrete raft or slab on which the boiler is installed. Wide use has been made of refractory and insulating concretes as a protective layer for these slabs where the temperature is likely to be above the limit for normal shingle concrete and in many cases, particularly in furnace construction, the slab has been constructed entirely in refractory concrete. The type of concrete will naturally depend on the properties required, such as strength, insulation value, etc., but in general, if the concrete is to be load-bearing, ordinary refractory concrete is used. An added advantage of refractory concrete is its lower thermal conductivity than normal shingle concrete or firebrick. Where the load is not excessive use is made of the greater insulation properties of insulating concrete which, for this application, would normally consist of a Ciment Fondu/calcined diatomite mix. As a compromise between the two a Ciment Fondu/expanded clay Aglite mix could be used which has a strength approaching that of refractory concrete and a thermal conductivity of 3½ B.Th.U./sq. ft./hr./deg. F./in. Refractory or "Alag" concretes have also proved very satisfactory for small boiler house floors where spillage of hot clinker can cause the disintegration of normal concrete.

Where shell-type boilers are fired by chain-grate stokers, both Ciment Fondu and "Secar 250" refractory concretes are commonly used for both stoker and ignition arches. A Ciment Fondu refractory concrete is quite satisfactory for the stoker arch, but for the ignition arches the more refractory "Secar 250" mixes are generally employed. The choice of a refractory aggregate will, of course, depend on the service conditions which are governed by:—(1) Firing rates; (2) Ash content; (3) Ash composition and melting point; (4) Combustion conditions; (5) Flame contour.

Fig. 4. An ignition arch fitted over a Hodgkinson chain-grate stoker formed of "Secar 250"/fused alumina.

In particularly severe conditions it is advisable to take advantage of the very high refractoriness and slag resistant properties of a "Secar 250"/fused alumina mix. A typical mix for the ignition arch is 1 vol. "Secar 250": 3 or 4 vols. fused alumina graded from ⅜ in. down to dust, whilst mix B (given in Table 3) is suitable for the stoker arch. The arches can be cast in-situ on simple wooden or metal shuttering or made up of pre-cast shapes. The latter method seems to be the more favoured since efficient compaction can be obtained by simply placing the units on a vibrating table, resulting in a denser and better quality concrete. It should be

noted that for in-situ work, compaction by vibration either with an immersion poker vibrator or by attaching vibrators to the formwork should always be carried out whenever possible. A typical example of a "Secar 250"/fused alumina ignition arch is shown in Fig. 4. These arches have proved extremely satisfactory and a life of two years and over is not uncommon. This life, however, may vary according to the severity of the conditions. More economic mixes of "Secar 250"/sillimanite or "Secar 250"/molochite concretes could, of course, be used where the conditions are not so severe.

In both pulverised-coal-fired, and oil-fired boilers, refractory concretes are frequently used for burner blocks and quarls, the type of concrete (i.e., ordinary refractory concrete or super-duty refractory concrete made with "Secar 250") being selected according to the existing conditions. The blocks or quarls are either cast in-situ or constructed of pre-cast units. Castable refractories have also proved very satisfactory for the linings of combustion chambers.

Owing to the improved life of refractory concrete linings for furnace doors, it has become common practice to line inspection doors, access doors, fire-level or guillotine doors with refractory concrete, the linings usually being cast in-situ into the metal frame or shell.

Walls and arches

Castable refractories have proved satisfactory for rear walls, downtake walls, and flat arches in Lancashire boilers, and are also used for the rear combustion chamber and arches of Economic boilers. They are eminently suitable for this application since they give the obvious advantages of monolithic construction, thereby eliminating the weakness of refractory brickwork joints, the breakdown of which gives rise to air leakages and the possible by-passing of effluent gases direct into the main flues. Faulty rear walls of Lancashire boilers are often replaced with refractory concrete without disturbing the side walls. In such cases it is probably advisable to place a thin packing of asbestos board between the ends of the rear wall and the brick side walls to allow for any differential expansion.

Refractory concretes have also been used for pre-casting a great variety of special shapes frequently required in boilers, and also for baffles. A typical example of a proprietary pre-cast baffle is shown in Fig. 5. This baffle is suitable for oil and coal-fired Lancashire and Economic boilers.

Satisfactory results have been obtained with the use of refractory concretes in the combustion chambers of vertical boilers. Complete combustion chambers have been constructed, made up of suitably designed pre-cast shapes consisting of four or more units with a vertical rebated joint. The choice of mix (i.e., either normal refractory concrete or super-duty refractory concrete) selected to suit existing conditions. Combustion chambers of this type have the advantage of being easily assembled and any faulty section can be independently replaced. Another successful use for refractory concrete is as an infill behind the firebricks of the combustion chamber in Cochran vertical boilers.

Packaged boilers

In an article entitled "Manufacturing a Packaged Boiler,"[2] R. H. Pipkorn describes how a castable

Fig. 5 (above). A precast Ciment Fondu refractory concrete baffle for either a Lancashire or Economic boiler, fired by oil or coal.

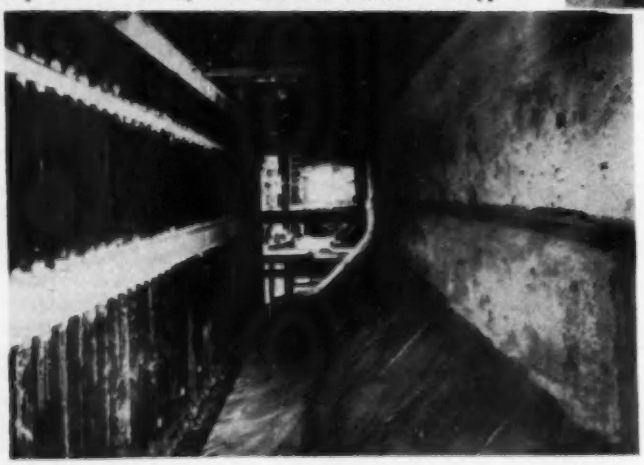


Fig. 6 (left). A bent tube baffle for a water-tube boiler, formed of Ciment Fondu castable refractory.

refractory is used in an American type packaged fire-tube boiler to line the casing of the rear head. This is preferred to conventional firebrick which has to be cut, shaped, and then cemented into place. The head is first lined with insulating brick, and the castable refractory placed and trowelled to the desired contour. The author suggests that with good design of the rear head, pre-cast units can be used which have the added advantage of quicker installation and the elimination of the necessity for holding firebrick stocks. Similar types of fire-tube packaged boilers are also manufactured in this country in which the rear combustion chamber is constructed of pre-cast units made from a proprietary castable refractory premix; the same premix is also used for door linings. The vapour steam generator is a coil water tube type and in standard models a castable refractory insulating premix is used for the base of the boiler on which the coil rests. Recently a much lighter packaged boiler of this type was required for carriage heating in trains hauled by Diesel locomotives and will, therefore, be subject to rather severe vibration. In this case it was decided to cast in-situ the collar and combustion chamber lining in a high temperature insulating castable. Since the operating temperature is of the order of 1,650 deg. C., a " Secar 250 "/bubble alumina mix was selected. The concrete was cast in-situ and, owing to the expansion characteristics of refractory concrete previously mentioned, together with the comparatively small dimensions of the combustion chamber, expansion joints were not considered necessary. The pad in the bottom of the boiler was cast in-situ with a lightweight " Secar 250 "/crushed H.T. brick insulating aggregate.

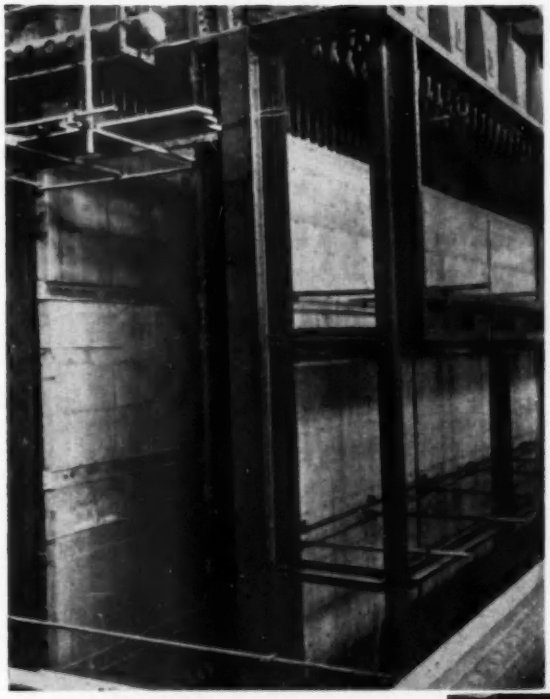


Fig. 7 (above). Economiser baffles for a water-tube boiler ; an example of the use of Ciment Fondu castable refractory premix.

Fig. 8 (right). Refractory concrete ash-hoppers of a large water-tube boiler, under construction at Brighton " B " power station.

Water-tube boilers

It is evident from the widespread use of castable mixes of both insulating and refractory concretes in large water-tube boilers for front and rear walls, insulating behind the tubes, insulation of economiser-casings, various types of baffles and as a backing behind the tangent base water tubes, further mention would seem unnecessary. The initial installation, and also major repairs, such as periodic relining, are normally carried out by specialist contractors many of whom manufacture their own premixes. Typical examples of the use of castable mixes in boilers are shown in Figs. 6 and 7.

In stoker-fired water-tube boilers, use is made of castable refractory mixes for constructing the divisional wall between grates. These are usually constructed of precast blocks and have proved superior to brickwork. Copings and fillets on the tops of walls to prevent accumulation of ash and dust is another satisfactory use. For applications such as ignition arches, where the temperature will exceed the limit of Ciment Fondu refractory concrete or where slag attack from the ash is severe, advantage should be taken of the higher refractoriness and improved slag resistance of " Secar 250 " mixes. Conditions in boilers, however, vary considerably, and the choice of the type of castable refractory will, therefore, depend primarily on the individual conditions existing in the boiler. In a typical installation, Ciment Fondu refractory concrete precast blocks have given a very satisfactory life of over seven years in a flat arch immediately over the chain grate fitted to a Babcock & Wilcox

water-tube boiler. The same mix has also proved satisfactory in this boiler for the rear wall and pillar lintol. The wall was cast in-situ in a Ciment Fondu refractory concrete behind wooden shuttering, the size of the wall, which was constructed by the Power Station's own labour, was approximately 10 ft. long by 7 ft. high by about 14 in. thick.

TABLE IV
REFRACTORY CONCRETE MIXES

SUGGESTED MIXES FOR VARIOUS CONCRETE THICKNESSES			AMOUNTS REQUIRED PER CU. YD. OF CONCRETE		
MIX A (6 in. thick or over)					
CIMENT FONDU	1 cu. ft.	or 1 cwt.	7.8 cu. ft.	or	6.3 cwt.
Coars aggregate (¾ in.—¼ in.)	3 cu. ft.	3¾ cu. ft.	23.4 cu. ft.		12.1 cwt.
Fine aggregate (¼ in. down)	2 cu. ft.	2½ cu. ft.	15.6 cu. ft.		10.3 cwt.
MIX B (1½ in.—6 in. thick or where the pattern is ore complex)					
CIMENT FONDU	1 cu. ft.	or 1 cwt.	8.6 cu. ft.	or	6.9 cwt.
Coarse aggregate (¾ in.—¼ in.)	2 cu. ft.	2½ cu. ft.	17.1 cu. ft.		9.4 cwt.
Fine aggregate (¼ in. down)	2 cu. ft.	2½ cu. ft.	17.1 cu. ft.		11.3 cwt.
MIX C (for mortar, jointing, or work of small dimensions)					
CIMENT FONDU	1 cu. ft.	or 1 cwt.	10.5 cu. ft.	or	8.4 cwt.
Fine aggregate (¼ in. down)	2½ cu. ft.	3 cu. ft.	26.2 cu. ft.		17.7 cwt.

MIX B will be found to be the most satisfactory Refractory Concrete for general purposes.

Refractory concrete is frequently used for lining ash and clinker hopper doors and also for lining various types of ash hoppers and pits. The hoppers and sluices are normally constructed from Ciment Fondu/crushed firebrick mixes using either mix A or mix B given in Table 4, while a typical example of a refractory concrete ash-hopper of the Karenna type is shown in Fig. 8. In the finished hopper, the refractory concrete surface is often topped with a course of firebricks. Since the temperatures are comparatively low, refractory concretes of improved strength and abrasive resistance properties can be obtained by increasing the cement content of the normal mix proportions by about 50 per cent. Ciment Fondu/ALAG mixes, described above, however, have a better resistance to abrasion than refractory concrete and it is interesting to note that tests with this type of concrete in a waterborne coke conveyor or trough where conditions are very severe due to fluctuating water temperatures, almost up to boiling point, and also severe abrasion from the coke, have so far proved extremely successful. An illustration of a coke trough with a lining of Ciment Fondu/ALAG concrete, applied by the gunning process, is shown in Fig. 9.

Oil-fired boilers

Recently, in order to promote better combustion conditions, particularly in oil-fired furnaces, the re-introduction of refractory walls in the combustion zone is being actively investigated. For instance, the boilers at one large power station were designed for both oil and coal firing but it was found that, due to the more rapid heat release when fired with oil, too much heat was transferred to the lower parts of the boiler tubes leaving insufficient temperature in the gases for efficient working of the superheater and economiser. This was overcome by introducing an appreciable amount of excess air which unfortunately created further problems by increasing the acidity of the gases due to the greater oxidation of the sulphur compounds, causing some corrosion of the economiser, and disintegration of the linings in the dust precipitators. This problem was solved by the use of refractory belts which facilitated the use of less excess air and so cut down appreciably the formation of SO_3 at the economiser, etc. The refractory belts were placed on the front and rear walls of the boiler, in line with the top of the lower burner, and extended to a height of 16 ft., with a width across the boiler of 30 ft. and a thickness of 2 in. Studs 2 in. long × ½ in. diam. were welded obliquely on to the tubes placed at 6 in. centres in line with the burners and at 12 in. centres above and below this line and extending to within ½ in. from the hot face. The belt was divided up into approximately 2 ft. square sections with hardboard and a castable refractory gunited on, each section being gunned separately as a precaution against lamination. Both belts were installed within 20 hours. The first test was with a proprietary castable premix (approximately 50 per cent. alumina) incorporating "Secar 250," and gave a life of about three months. Subsequent trials with the same mix, however, on belts with a modified design were much more satisfactory, and in fact gave a life of more than twice the original. The period between statutory shut-downs is approximately 18 months and a belt life of 18 months to coincide with this period would obviously be most convenient. In an endeavour to obtain this life it was decided to employ a more refractory mix and since temperatures in the combustion zone were stated to be approximately 3,000 deg. F., a "Secar 250"/fused alumina mix was selected. Two "Secar 250"/fused alumina mixes—one in the proportion of one part "Secar 250" to six parts fused alumina by weight (alumina content approximately 96 per cent.) and the other of one part "Secar 250" to five parts fused alumina by weight

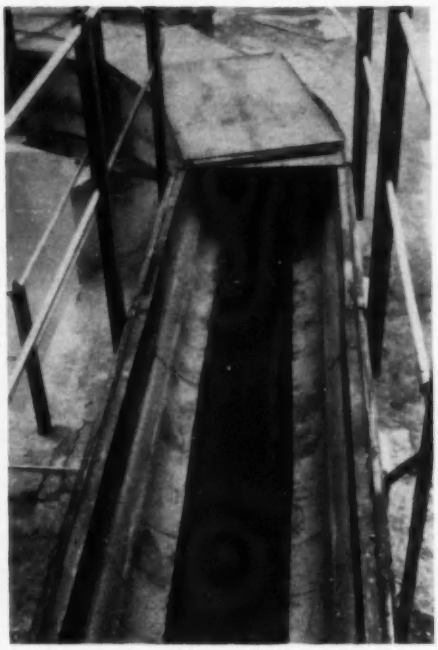


Fig. 9. A Ciment Fondu/ALAG lining was used in this example to replace the bottom tile in a coke-trough.

(alumina content approximately 94½ per cent.)—were tested on two of the boilers and have given a life of over one year, which is much longer than the previous castable or ramming mixes employed. A completed " Secar 250 "/fused alumina belt is shown in Fig. 10. These mixes were considered very satisfactory although the fused alumina mix has a slightly higher thermal conductivity which affects to a small degree the efficiency of the boiler. It is, therefore, intended to instal a trial section of the belts with a mix of approximately the same refractoriness but of lower thermal conductivity which is achieved by using a bubble alumina aggregate. High temperature insulating concretes made with this material and " Secar 250 " have thermal conductivity of 6 B.Th.U./sq. ft./hr./deg. F./in. An added advantage of this mix is that it is more economical than a mix employing a dense fused alumina.

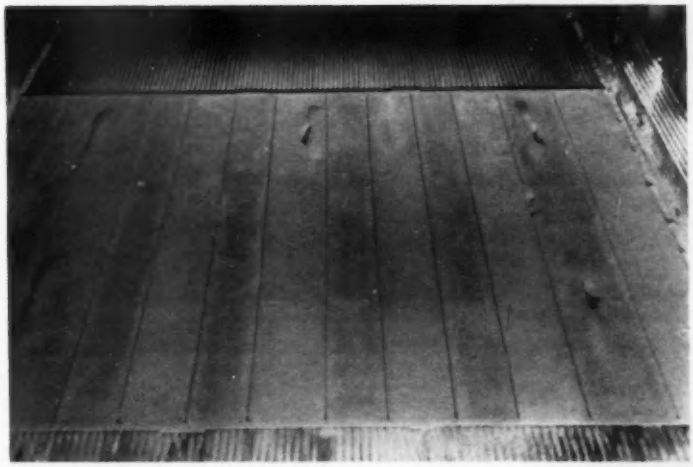


Fig. 10 (left). A completed refractory belt formed of " Secar 250 "/fused alumina, and provided for a large water-tube boiler at a C.E.G.B. power station.

Refractory belts, however, do not appear to give a complete answer to the problem and tests have been carried out with a refractory false bottom under the burners. These trials, however, indicate that this also is not the complete answer and it is thought that if a " Secar 250 "/bubble alumina mix does not prove entirely satisfactory a possible solution may be the combination of a false bottom and a shorter refractory belt.

Flue and chimney linings

For heat conservation purposes it is customary to employ insulating concrete mixes with vermiculite or calcined diatomite aggregates between the refractory linings and the steel casings or exterior brickwork of the boilers. The vermiculite mix is possibly more satisfactory, probably because of its light weight and better insulation properties. It has, however, little mechanical strength, and where greater strength is required, calcined diatomite mixes would be more suitable. A very popular method for lining metallic ducting (e.g. flues) is by the cement gun process, although the linings can, of course, if preferred, be cast in-situ behind shuttering or hand-rendered or, indeed, made up of precast shapes. The choice of aggregate will depend on the properties required but, in general practice, a Ciment Fondu/calcined diatomite mix seems to be preferred, but where higher strengths are required the normal refractory concrete mix is usually substituted. Where the flues are underground an easy and popular method of construction is to cast the selected concrete on the floor of the trench on which is centred a simple wooden former of the required shape of the flue and the concrete cast over and around it. The former can be pulled along the trench after the concrete has hardened, ready for the next section; a layer of waterproof paper over the top of the former makes its removal much easier. An example of this type of underground flue is shown in Fig. 11.

Fig. 11 (below). An underground flue being constructed of Ciment Fondu/refractory concrete.

Another very satisfactory application of Ciment Fondu mixes is for the lining of chimneys. This type of cement is extremely suitable for such linings since it has, in addition to its refractory properties, a very high resistance to the dilute sulphur acids which are present in the flue gases. The type of aggregate used will, of course, be dependent on conditions in the stack, for

example, temperature of flue gases, insulation value required, etc., but in general, for temperatures up to about 400 deg. F. normal silica sand is used. For temperatures in excess of this the use of sand aggregate is not recommended owing to the high thermal expansion and contraction of silica and either insulating or refractory aggregates should be substituted. The most popular method of application is by the gunite process, wire mesh reinforcement being attached to the stack, as described above, and the Ciment Fondu mortar is "shot" on.[3]

Conclusions

It is evident that the increase in the use of castable refractories is very pronounced and that they are gradually replacing the traditional refractories in a great many applications, not only in boiler installations but also in the refractory field in general. This is, perhaps, particularly noticeable in water-tube boiler installations where in large power station boilers between 70 and 90 tons of castable refractories per boiler are now used to the almost complete exclusion of the traditional pre-fired refractories. Although Ciment Fondu castable mixes have been in use for many years, particularly in water-tube boilers, the introduction of "Secar 250" with its higher refractoriness has greatly increased the scope of application of castable mixes and has given to the refractory and boiler plant engineers the advantages of monolithic construction for practically any application up to 1,800 deg. C. "Secar 250" has also enabled suppliers of castable refractory premixes to considerably extend the range of their products, and refractory and boiler engineers are now able to select a castable mix which is suitable for almost any application.

References

1. Heindl. R. A. and Post. Z. A., J. Amer. Cer. Soc., 1954, 37, (5), 206.
2. R. H. Pipkorn, Modern Power and Engineering, Canada, July, 1959, p. 82.
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A STEWARTS AND LLOYDS REORGANISATION

An important development, involving the creation of a new division, has taken place within Stewarts and Lloyds organisation. This is the setting up of the Pipework Engineering Division, which will be responsible for the making and marketing of all forms of manipulated pipework. Stewarts and Lloyds Limited have been making and fabricating pipework for almost as long as they have been manufacturing steel tubes—one hundred years as individual companies, and more than fifty years since their amalgamation. The increasing and varying needs of industry, and the growing complexity of technical requirements, have been met by the company over the years. Now the organisation has been examined and streamlined and P.E.D., as the division will be known, has been set up to co-ordinate the manufacturing resources, technical experience and practical and scientific knowledge of Stewarts and Lloyds in this connection, and to deploy them to the best advantage. The division will be under separate management with its own sales, engineering and manufacturing departments.

In the past twelve months during which the reorganisation has been going on, the objective has been to create a division which will include the design, manufacture, erection or site fabrication of entire pipework installations with ancillary equipment or the supply of pipework to customers' own drawings or from dimensions taken on site. A radiography service is also available to customers for the non-destructive testing of fabricated parts.

Works have been allocated to deal with the many small and often short-notice orders that are received; typical are the London Fabricating Shop in Pudding Mill Lane, Bow, and the Globe Works, at Wednesbury, Staffs., which was founded over a hundred years ago and became part of the Stewarts and Lloyds organisation in 1935. To meet large orders there are available the full facilities of up-to-date shops at Tollcross, Glasgow, which gives specialist attention to high-pressure and high-temperature piping, and at Coombs Wood, near Birmingham, which deals in both high and low-pressure pipework in a wide range of sizes, supplies steam receivers, separators and other pressure vessels, and fabricates small-bore piping and coils. The Phoenix Works, Glasgow, caters for commercial requirements in the low pressure categories and for orders for oil line refinery manipulated pipework and manufactures butt weld fittings. The special needs of nuclear plant have been provided for by the erection at Tollcross of a "clean condition" shop where pipework or ancillary equipment for reactors can be assembled under the stringent conditions of cleanliness required. P.E.D. provides pipework not only in mild steel normally used in industry but in low or medium alloy or stainless-steel, non-ferrous metals and cast-iron.

Manipulated high-pressure pipework in the assembly, inspection and despatch bays at the Tollcross works of Stewarts and Lloyds Limited.

Officers of the new division, which will be under the chairmanship of Mr. James Carson, a director of Stewarts and Lloyds, will be:—Managing Director—Sir Allan Eliott Lockhart, C.I.E.; General Manager, Sales and Engineering—Mr. G. T. T. Rheam, O.B.E., T.D., B.Sc. (Eng.), A.C.G.I., M.I.Mech.E., A.M.I.E.E.; General Manager, Production—Mr. A. H. Kynaston, V.R.D., A.M.I.Mech.E., A.M.I.Prod.E., Assoc.-Fel.Inst.Pet., Lieut.-Commander, R.N.R. (Ret.).

Commenting on the formation of the division, Sir Allan Eliott Lockhart, said: "What we have done, in effect, is to co-ordinate the resources of Stewarts and Lloyds in this particular sphere and create an overall organisation so that any order, large or small, can be dealt with in the most efficient and expeditious way. We are ready now to deal with any work from the bending of a single pipe to the designing, manufacturing and setting up of a complete installation and to manufacture suitable products of a general engineering nature."

Offices of P.E.D. are at:—Broad Street Chambers, Birmingham, 1. Tel.: Midland 2700, and 41, Oswald Street, Glasgow, C.1. Tel.: Central 7011.

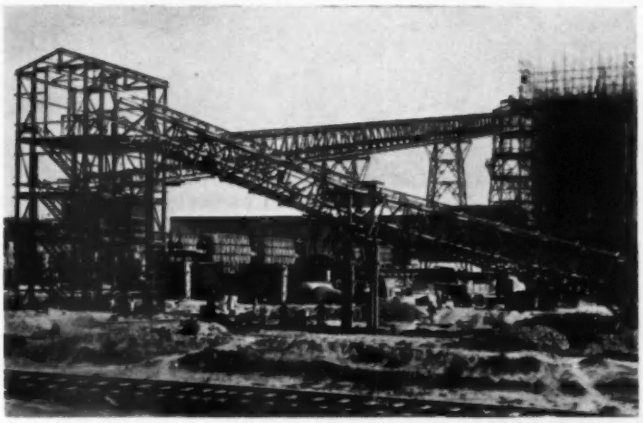
New Steelworks Plant in India

Inauguration of the first stage of £105-million project at Durgapur, West Bengal

ON December 29th, 1959, the first stage of the Durgapur Steelworks, in West Bengal, India, was officially inaugurated by the President of India, Dr. Prasad. The contract for this vast undertaking, valued at £105-million, was placed with the Indian Steelworks Construction Co. Ltd. (ISCON), a consortium of British firms; while financial assistance in the form of a loan was arranged between the British and Indian Governments.

The Durgapur Steelworks, which are located about 118 miles from Calcutta, have been designed for an ultimate annual production of 1-million tons of steel ingots, and when complete, in addition to the actual steelworks plant, will include a coke-oven installation with associated coal-preparation and by-product recovery plants; together with a power plant. ISCON, the consortium formed specially to carry out this work comprises the following 13 British firms: Davy and United Engineering Co. Ltd.; Head, Wrightson & Co. Ltd.; Simon-Carves Ltd.; The Wellman Smith Owen Engineering Corporation Ltd.; The Cementation Co. Ltd.; the British Thomson-Houston Co. Ltd. [now A.E.I. (Rugby) Ltd.]; The English Electric Co. Ltd.; The General Electric Co. Ltd.; The Metropolitan-Vickers Electrical Co. Ltd. [now A.E.I. (Manchester) Ltd.]; Sir William Arrol & Co. Ltd.; The Cleveland Bridge & Engineering Co. Ltd.; Dorman, Long (Bridge & Engineering) Ltd.; and Joseph Parks & Son Ltd. This consortium co-ordinated the work of preparing tenders and specifications, which were duly approved by the Indian Government, and the contract for the construction of the works was signed in October, 1956.

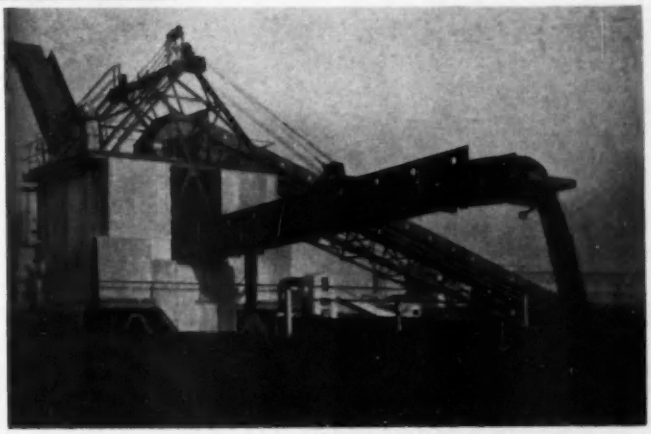
The Durgapur Steelworks project has been planned for construction in four stages, and is due for completion in 1961. The first stage, which is now in operation, comprises one of three batteries of coke-ovens; the first of three blast-furnaces; the foundry; and part of the power plant. The entire coke-oven installation, coal-preparation plant, by-product plant, power plant, and steam and gas distribution, are being supplied by Simon-Carves, Ltd., Cheadle Heath, Stockport, who are also acting as sub-contractors to other ISCON companies, and in this capacity are carrying out a large amount of refractory brickwork installation.



(Above). General view, showing part of the by-product plant and a section of the coal-conveyor gantries, under construction.

Coal preparation plant

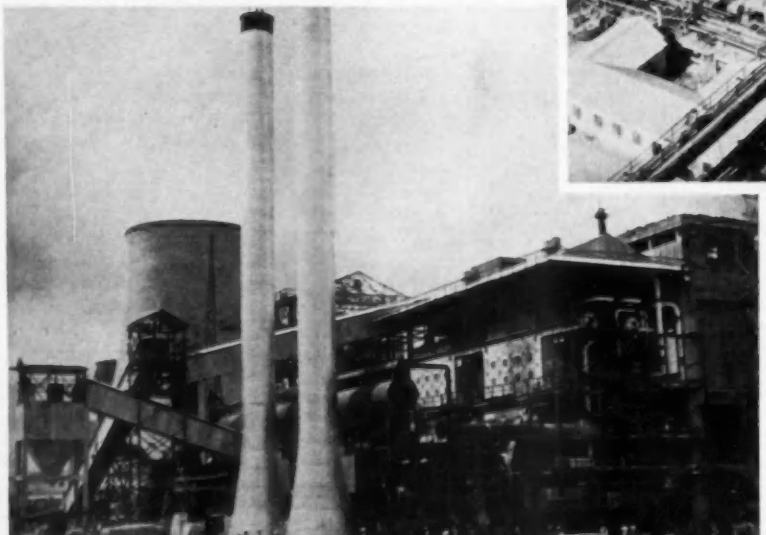
The coal-preparation plant has been designed to handle some 700-tons/hr. from the rail-sidings to the primary coal-crushers. Incoming wagons are discharged by means of three wagon-hoists and tipplers, the coal then being conveyed by two separate belt-conveyors to the primary coal-crushers where it is reduced to a maximum size of 3-in. The two coal streams normally comprise (a) coal to be washed, and which is transferred to a washery; and (b), coal that does not require washing, and which is delivered direct to a stocking and blending plant. The coal-washery is designed for an input



(Right). The wing-tippler associated with the Robins-Messiter coal stocking and blending installation.

capacity of 360-tons/hr. of coal up to 3-in. in size, and of high ash content, received from the Jharia coalfields. The washed Jharia coal is blended with unwashed coals of lower ash content received from the Baraker and Disergarh coalfields, in such proportions as to give a blend which can be carbonised to produce an acceptable blast-furnace coke. The washing process also yields a residue which can be re-separated to produce a high-ash discard, and a middlings product suitable for use as a fuel for firing the boilers installed in the steelworks power station, or in the Durgapur thermal power station of the Damodar Valley Corporation. Although designed for this specific duty, the washery is sufficiently flexible to enable other types of coals to be treated if required.

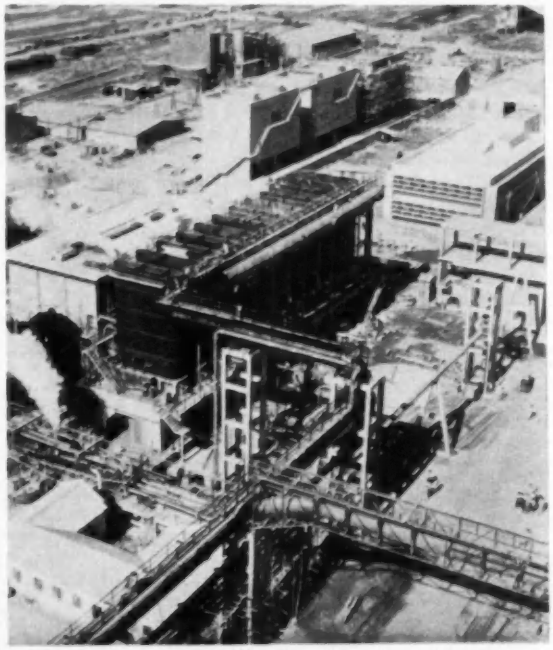
The washed and unwashed coals are stocked, blended and reclaimed for the coke-ovens by the Robins Messiter system, in which travelling wing-trippers deposit the coal on open ground in long parallel stockpiles, the various types of coal being deposited in successive layers so that each stockpile contains the ingredients of a correct blend for carbonisation. The coal is reclaimed by travelling machines with oscillating rakes which continuously remove a cross-section of the stockpile and deposit it on underground conveyors; reclaiming and blending of the different coals comprised in a stockpile thus takes place simultaneously, so that the conveyors deliver an accurate coking blend to the final crushers, and thence to the coke-oven coal service bunkers. Using two reclaiming machines at a time, coal is reclaimed at a rate of 550-tons/hr. The Robins-Messiter system is well known as a method of ore-blending, but Durgapur is only the second example of such an application to coal-handling at a coking plant. The first was at the steelworks of John Summers & Sons Ltd., at Shotton in the United Kingdom, where it has been in successful operation for a number of years. The reclaimed coal is passed through hammer-mills and reduced in size, whereby 80 per cent. will pass through a $\frac{1}{8}$ in. square mesh. It is then conveyed to the two 4,000-ton coke-oven service bunkers.



(Right). The boilers and part of the fuel-handling plant under construction. Simon-Carves Limited were responsible for this work, and also for the whole of the by-product plant.

Coke ovens

The Simon-Carves coke-oven installation will ultimately comprise three batteries of 78 ovens each, making a total of 234 ovens, designed to carbonise approximately 5,200-tons/day of dry coal, and producing some 3,900-tons of run-of-oven coke, of which about 3,300-tons will be $+\frac{3}{4}$ in. size, suitable for the blast furnaces; the $-\frac{3}{4}$ in. size being screened and graded into three different sizes for sale. The coke-ovens are of the compound-underjet-type, which can be heated either by burning part of the rich gas produced in the ovens themselves, or by lean gas from the blast furnaces. Lean blast-furnace gas is utilised to the maximum extent possible, in order to release the rich gas for use in other steelworks plant, and the DVC Durgapur Thermal Power Station.



(Above). View from the south-east, showing the primary condensers, exhauster house, detarrers, and the primary water-cooling towers.

By-product plant

When all three coke-oven batteries are in service they will produce approximately 2.4-million cu. ft./hr. of gas which will be passed to the by-product plant in two

streams, by two steam-driven turbo-exhausters. Tar, ammonia, benzole and naphthalene will be removed from the gas at various stages throughout the by-product plant; the clean gas then passing to a gas-holder for ultimate distribution. The approximate output of the by-product plant when in full operation will be:—

Gas	60-million cu. ft./day
Sulphate of ammonia	57-tons/day
Crude tar	155 ,,
Benzene	6,240-gal./day
Toluene	885 ,,
Xylene	180 ,,
Solvent naphtha	145 ,,

Power station

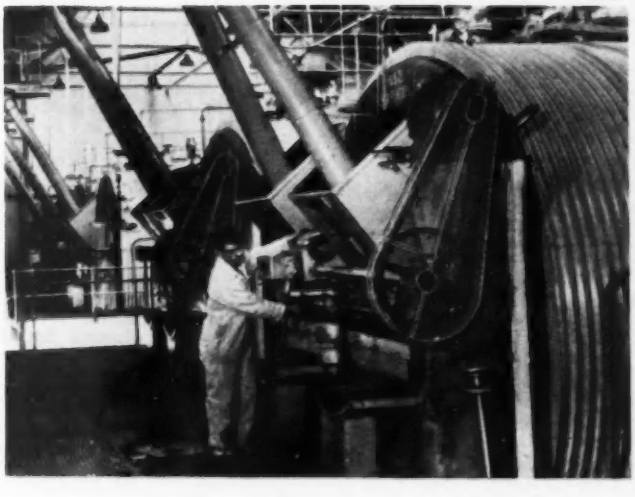
The main function of the power station plant is to provide high-pressure steam to drive the four, 12,000 h.p. blast furnace turbo-blowers, but it also supplies steam for power and process work on the coke-oven by-product plant, and it has sufficient electrical generating capacity to meet the essential needs of the steelworks in the event of failure of the main outside electrical supply; three 5,000-kW turbo-alternator sets are being installed, and there is provision for the installation of a 20,000-kW turbo-alternator, at some future date. Four tri-drum water-tube boilers, each with an evaporative capacity of 150,000 lb./hr. at 500-lb./sq. in., and 775 deg. F., were supplied by Simon-Carves Ltd. All the boilers are designed for firing with coke-oven or blast-furnace gas, two being also equipped with chain-grate stokers for firing coal or coke-breeze—which fuels can be burned either separately or by sandwich-firing. The power station is complete with fuel and ash-handling plants, water-treatment plant, cooling-water circulation system and cooling towers, while a constructional feature is that only the boiler firing-aisle and the turbine house are enclosed—the boilers themselves being of the outdoor-type.

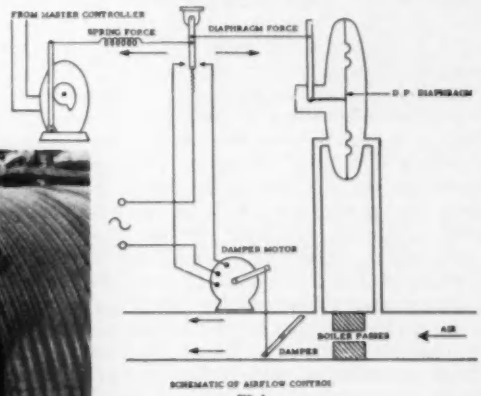
Distribution services

Simon-Carves Ltd. were also responsible for the design, fabrication and construction of the whole of the pipework and control equipment for distribution of gas, steam and tar. Two dry-gas-holders are provided, one of 3-million cu. ft. capacity for blast-furnace gas, and one of 2-million cu. ft. capacity for coke-oven gas. The actual services cover: (1) steam distribution to the turbo-alternators and turbo-blowers, the supply to various pumps and prime movers in the coke-oven by-product plant, and for miscellaneous heating, atomising, deaerating and purging processes; (2) distribution of clean blast-furnace gas to gas-holder and to blast-furnace stoves, soaking pits and mill furnaces; (3) distribution of clean coke-oven gas to gas-holder and to the coke-ovens (when on rich-gas heating), the power station boilers, the steel plant, and the lime and dolomite kilns; (4) distribution of coke-oven gas to the thermal power station of the Damodar Valley Corporation; and (5) distribution of coal-tar-fuel from the coke-oven by-product plant to the open-hearth steel furnaces.

Efficient Automatic Control Application

INCREASED efficiency has been achieved with three of the six boilers at the East Kilbride works of Rolls-Royce Ltd., by the installation of an automatic control system. The six boilers, supplied by John Thompson (Wilson Boilers) Ltd., are each rated at 15,000 lb./hr. at 150 lb./sq. in. They are arranged in two groups of three, one group supplying steam to calorifiers for spaceheating, and the other steam for works processes. Two G. & J. Weir Ltd., direct-acting feed pumps are provided between the two groups of boilers. Coal is delivered through a grid to the boot of a bucket-elevator, and thence to the chutes of the boiler service hoppers. The stokers used are of the Low-Ram type, supplied by James Hodgkinson (Salford) Ltd., and driven by





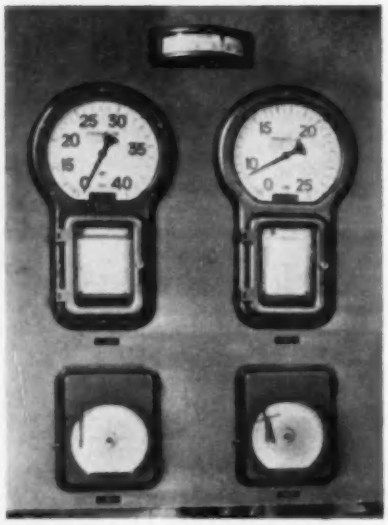
SCHEMATIC OF AIRFLOW CONTROL
FIG. 1

(Above). Schematic arrangement showing method of operation of the air-flow control.

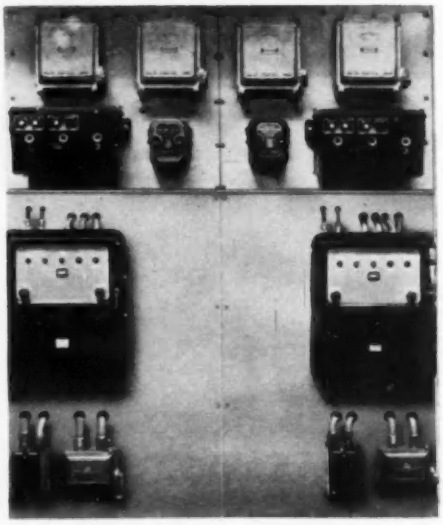
(Left). Five of the six John Thompson (Wilson Boilers) Limited boilers, each of which is rated at 15,000-lb./hr. The boilers have raised firing platforms, under which there is a conveyor taking ash to an external disposal hopper.

constant-speed a.c. motors. Ash is raked directly on to a submerged conveyor belt which runs below the whole length of the raised firing-platform to an external disposal hopper.

Kelvin & Hughes Ltd. supplied the original instrumentation when the boilers were installed during 1957, and they were also responsible for the conversion to automatic control of the three boilers; this work being completed in August 1958. The original instrumentation comprised individual panels facing each boiler and containing draught-gauges, lossmeter, steam-flow indicator recorder and integrator instruments, while in addition, an integrating panel in the boiler superintendent's office summated the steam-flow and temperatures of the outgoing process and space heating mains. This panel also contained steam-pressure recorders, condensate tank temperature recorders and an ambient temperature recorder.



(Left). The integrating panel which is located in the boiler superintendent's office.



(Right). Master combustion controllers on the individual boiler panels.

The new automatic control system comprises a master steam-pressure controller, located in the superintendent's office, and connected to the main steam header to provide an advance warning of fluctuating loads. Peaked signals, proportional to the fluctuating steam pressures are relayed by the master controller to the individual combustion controllers regulating the coal feed and airflow to each boiler. Coal feed is regulated by the cyclic operation of the constant-speed motors driving the mechanical stokers; the running time being proportional to the load as indicated by the master controller. Air flow control is affected by a motorised-damper, operated through a push-rod and reduction-gear. Pressure differential across the boiler passes is measured and fed to a diaphragm unit. The output of the diaphragm is opposed by a control spring which is tensioned by a square law cam moving in response to the load signals. The resultant force positions a switch which controls the damper motor, thus the air flow is subject to a closed-loop-control, and is independent of the characteristic of the damper motor. Provision is made on the combustion controllers to enable the boiler operator to change over to manual control, or to adjust the heat regulation as required. The controllers are also balanced to permit load sharing and once set, should require no further adjustment.

Tests were carried out during the three winter months —October to December 1958—and, as accurate and detailed reports had been maintained over a long period when operating with manual control, comparisons between the two systems under all load conditions were possible. During the period covered by the tests, the following figures were obtained:

Manual operation

Average calorific value of fuel	=	12,000 B.Th.U./lb.
Water evaporated (lb.)	=	38,412,460 lb.
Fuel burnt	=	4,717,370 lb.
Water evaporated/lb. of fuel	=	8.1 lb.
Average boiler feed water temperature	..	162 deg. F.

Automatic control

Average calorific value of fuel	=	12,000 B.Th.U./lb.
Water evaporated	=	53,712,700 lb.
Fuel burnt	=	6,118,200 lb.
Water evaporated/lb. of fuel	..	8.7 lb.
Average boiler feed water temperature	=	162 deg. F.

By the use of Callendars steam tables, these figures indicated an efficiency of 71.6 per cent., for the boilers under manual control, and 76.9 per cent. for those under automatic control—an increase of 5.3 per cent.

The main advantage of the automatic system as opposed to manual control of this, and similar boiler plants, would appear to be the ability to maintain a high-efficiency over long periods.

The Minister of Power, replying to a question raised in the House of Commons recently, as to the amount spent annually on research into the uses of coal by the Gas Council, the National Coal Board and the Central Electricity Generating Board, said that this year the Gas Council was spending £120,000 on research into coal gasification, and the National Coal Board and C.E.G.B. £680,000 and £130,000 respectively, on coal utilisation. The Minister said further uses of coal were at present being examined by the Wilson Committee, which would shortly, he hoped, be reporting.

RECENT *Equipment* AND *Accessories*

Combined temperature controller and indicator

A new indicating temperature controller, introduced by Honeywell Controls Limited, has been designed for heating and cooling operations, and serves the dual-purpose of controlling and indicating temperatures in ovens, cookers, plating-baths, dryers and similar industrial applications. A highly sensitive, remote bulb, liquid-filled thermal system operates a single-pole, double-throw, Honeywell micro-switch which can either open or close a circuit in response to a temperature rise. A selection of ranges is available from −50 deg. F. to +1,200 deg. F. Both case and capillary are fully-compensated for ambient temperature variations. The set point can be changed by means of a knob on the front of the case, and both the indicated temperature and set point are made clearly visible by magnifying windows. The steel case is provided with slotted mounting brackets so that the controller can be either surface mounted on a wall, or flush mounted in a panel. (*Honeywell Controls Limited, Ruislip Road East, Greenford, Middlesex.*)

Fig. 1. The new Honeywell indicating temperature controller has been designed to serve a number of industrial applications. (Honeywell Controls Limited.)

Insulation protection

Texolag insulation protection which has been introduced by R. A. Brand and Co. Ltd., Letchworth, Hertfordshire, is a plastic coating system for preserving insulation materials on pipelines, storage tanks, reaction vessels and other types of process equipment. Most insulating materials tend to disintegrate if they are subject to mechanical damage, and those used on low-temperature lines and vessels require to be protected from the penetration of condensed moisture which would freeze and force off the insulation materials. In addition, chemical plant insulation may be exposed to spillage or leakage of chemicals. The materials and techniques of the Texolag system have, therefore, been designed for the protection of insulation where vapour sealing and resistance to solvents or corrosive atmosphere is required. Continuous pipelines and regularly-shaped vessels may be protected by using Texolag base, which consists of fabric impregnated with a plastic composition and is wrapped round the insulation surface over a coat of sealing compound and then sealed with a special lacquer. Irregularly-shaped vessels, flanges and valves may be treated similarly or else a sprayable solution can be used to produce a continuous plastic film. The lacquer for sealing the system can be supplied pigmented to any colours, and may, therefore, be employed for colour coding. Modern foamed plastic materials may be protected with Texolag. The system may be used on any equipment where the temperature of the external surface of the insulation does not exceed 160 deg. F. or fall below −30 deg. F.: it is very resistant to spread of flame, thus reducing fire hazards. (*R. A. Brand & Co. Ltd., Letchworth, Herts.*)

Belt-weighing machine

The Merrick Scale Mfg. Co. Ltd. have recently introduced a new belt weighing machine, known as the SV Weightometer. The new unit can be fitted to horizontal or inclined conveyors, having either flat or troughed idlers, and will total the weight of material passed over the conveyor. The Weightometer incorporates a mechanical integrator which continuously multiplies two varying quantities, the varying load on the conveyor, and the slightly varying belt speed. The speed of any conveyor, whilst usually considered as constant, in reality varies slightly with the load, and in weighing, unless these conditions are taken into consideration, any final results will be erroneous. The new weigher can be supplied to accommodate any conveyor capacity and belt speed; while both electronically- or pneumatically-operated instruments, can be supplied with the machine. The weight recorder associated with the weigher does not necessarily have to be adjacent to the conveyor. Advantages claimed for the machine are that it can be fitted to existing conveyors with a minimum of modification to the structure; simplicity of design; low headroom requirements; and an accuracy of $\pm \frac{1}{2}$ per cent. of the true weight passed when the conveyor is operating under full load conditions. (*Merrick Scale Mfg. Co. Ltd., Albert Street, Bulwell, Nottingham.*)

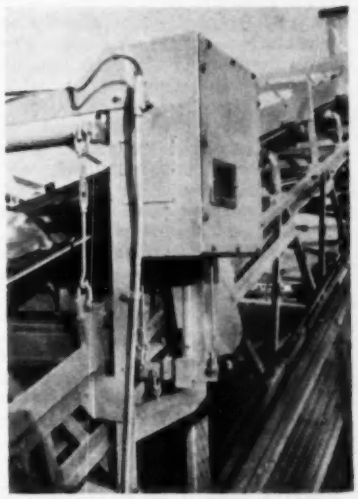


Fig. 2. The new SV Weightometer fitted to an inclined conveyor. (Merrick Scale Mfg. Co. Ltd.)

Float-operated mercury switch

One of the requirements of insurance companies in connection with the insurance of automatically controlled boilers, operating without regular supervision, is the provision of an independent over-riding safety control that will cut off the fuel and air supply to the burners or stokers, and operate an audible alarm when the water-level in the boiler falls to a pre-determined low-level. To

meet this requirement Royles Limited have made available the type-FC1-R float-operated mercury switch which has now been approved by the Associated Offices Technical Committee of the leading insurance companies, and also other insurance companies. The type FC1-R control unit operates in conjunction with a relay controlling an alarm. The mercury switch is arranged so that if the water-level in the boiler falls to a pre-determined low-level, the float will operate the mercury tube in a downward direction and de-energise the relay. This operation of the relay cuts off the fuel and air supply motors and, at the same time, switches on a battery-operated alarm bell. An external hand-lever is provided for re-setting purposes. Designed to operate at pressures up to 150-lb./sq. in., the control arrangement is such that it " fails-to-safety " on an electrical supply failure, and can only function again after being manually re-set if the water has fallen to an unsafe level. (*Royles Limited, Irlam, Manchester.*)

Photo-electric oil burner control

The Rheostatic Co. Ltd., have recently introduced an entirely new Satchwell instrument, the DG control, which in conjunction with a PE3 photocell, provides for fully-automatic operation of small oil burners with a consumption up to 4-gal./hr., in response to their controlling thermostats. The photo-sensitive cell ensures safety in operation, and provides a quick shut-down in the event of flame-failure. No thermionic valves are used in the control and the number of expendable parts has been reduced to an absolute minimum. The control box is particularly small, making it suitable for mounting on the oil burner, while the photocell housing is arranged for mounting in the draught-tube of the burner. In operation, immediately the controlling thermostats call for heat, the control relay closes, which energises the ignition transformer. Approximately fifteen seconds later, the burner motor is started. If the flame is established and the photocell illuminated, the relay switches off the ignition, but the motor circuit is maintained, and the burner continues to run until the controlling thermostat limit is reached. If the oil does not ignite on starting, the photocell will not be illuminated, and a thermal lockout timer will switch off the burner motor within approximately seventeen seconds. The burner cannot be started again until the lockout switch is reset manually by depression of the push button in the control box lid. Terminals are provided, so that an external alarm or signal can be connected to indicate that lockout has occurred. In the event of flame-failure, ignition is re-established, but if the flame is not re-ignited, the control locks out in approximately ten seconds. No purge period is provided, as the ignition circuit is re-established immediately the flame fails. A further safety feature is designed to operate in

Fig. 3. The Satchwell " DG " photo-electric oil-burner control with PE3 photocell head. (The Rheostatic Co. Ltd.)

the event of an electricity supply failure, while in addition the control is designed so that in the event of abnormally low supply voltage, safe operation is always ensured. (*The Rheostatic Co. Ltd., Slough, Bucks.*)

New design of bag filter

A further addition to the range of dust collection and control plant manufactured and marketed by the Gas Cleaning Division of W. C. Holmes & Co. Ltd. is the Holmes-Retroflux bag filter, developed by Standard Filterbau Gesellschaft m.b.H. of Munster, and now manufactured under licence in the United Kingdom. This unit is particularly suitable for those applications where high dust burdens are encountered, and/or dusts of an adhesive nature have to be collected. In operation, the dust-laden air enters the header within the casing and is distributed to the inside of the filter bags, the air and dust moving in the same direction. The tendency of the dust to settle by gravity is not impeded by air currents as the air passes through the filter bags radially and the air velocity gradually diminishes to zero at their lowest end. The dust collected on the inner surface of the filter bags is continuously dislodged by the passage of high velocity air jets through the fabric in the reverse direction to the main air stream. The dislodged dust falls by gravity to the worm-conveyor or hopper below. The use of high-velocity air jets is a design feature which dispenses with the rapping or shaking mechanism and separate compartments encountered in other types of bag filters. The jet tubes have a narrow slot in the face which is in contact with the filter bag, and are specially shaped and finished to avoid damage to the fabric. The ends of the tubes are set in hollow frames which are suspened by chains, and are supplied with high-pressure air from a blower via a flexible hose. The frames operate in counter-balanced pairs when large volumes of air are being filtered; each frame is capable of cleaning the complete length of up to 36 bags. The jet tubes are mounted in pairs, one pair being positioned approximately 3 in. below and at 90 deg. to the other, so that progressive cleaning of the filter bags can be achieved efficiently and without damage to the fabric. Each jet tube

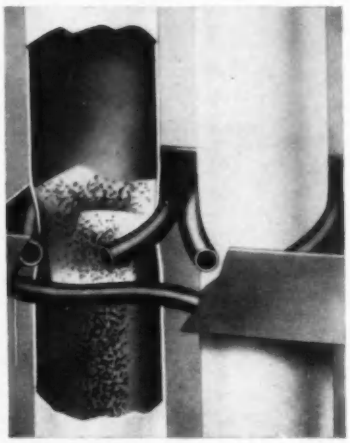


Fig. 4. Cutaway view showing a section of hollow frame and jet tubes around two filter bags. (W. C. Holmes & Co. Ltd.)

is in contact with the surface of the bag over a quarter of its circumference only, and in operation the bag becomes slightly elliptical in shape as each pair of tubes travels along its length. This arrangement ensures that the bag is not constrained in any way; creases do not form in the fabric and wear is reduced to such an extent that filtering media such as glass fibre can be used successfully when handling hot flue gases. The reciprocating frames carrying the reverse jet tubes travel at very slow speed, and this also reduces wear and tear on the material of the filter bags. An advantage claimed for the Holmes-Retroflux bag filter is that each filter bag is continuously and efficiently cleaned over its entire surface area; the high-velocity jet

of air which passes through the fabric being measured in thousands of ft./min. compared with less than 10 ft./min., the normal filtering air speed. One important result of this efficient cleaning is that the filter resistance can be maintained at approximately half of that normally experienced, without sacrificing any drop in efficiency. An appreciable saving in power consumption is, therefore, achieved. (*W. C. Holmes & Co. Ltd., P.O. Box No. B.7, Turnbridge, Huddersfield.*)

High-speed coal elevator

The latest development of James Hodgkinson (Salford) Limited is the high-speed screw elevator. It has been designed primarily for handling small coal for boiler firing purposes, where for one reason or another it is not convenient, or possible, to prepare a concrete ground-hopper or pit. For feeding the hoppers of "Low Ram," chain-grate or underfeed stokers under such circumstances it is claimed to be ideal. The

Fig. 5. The Hodgkinson high-speed screw-elevator arranged to feed coal on to a Hodgkinson chain-grate stoker. [James Hodgkinson (Salford) Limited.]

elevator consists of a steel tube in which rotates a worm, housed in totally-sealed, self-aligning ball-bearings, and driven by a constant-speed, totally-enclosed motor mounted on a platform at the head of the casing. A short standard chute extends from the head, to which an additional section or breeches piece can be added, provision being made for this to be swivelled to suit site conditions. At the tail, the worm is exposed for the entry of coal, while an adjustable device enables the head to be supported from any convenient structure in the boilerhouse. Each unit will handle up to 1½ tons of smalls per hour, and feed direct to the stoker simply by resting the tail on a pile of coal and lifting the head into position over the stoker hopper. The elevator is entirely self-cleaning, and no running maintenance is required, since the bearings are grease packed and sealed for life. Costly erection expenses and delays are eliminated—the machine can be working within half an hour of delivery. The high-speed screw elevator is supplied in six standard lengths—13 ft. to 18 ft. inclusive. [*James Hodgkinson (Salford) Limited, Ford Lane Works, Pendleton, Salford, Lancs.*]

Hydrostatic tank contents gauge

A new pressure-bulb-type hydrostatic tank contents gauge, manufactured by Firth Cleveland Instruments Limited, a member of the Firth Cleveland Group, has been designed to measure the head of liquid in non-pressurised tanks. The indicator associated with the gauge can be placed up to a distance of 250 ft. from the tank and arranged to show, by a dial and pointer, either the depth of liquid or the actual amount of liquid in the tank. The gauge is completely self-operative and offers continuous indication. It is supplied as two units, transmitter and indicator, together with an airline and connectors. The tank liquid fills the lower chamber of the transmitter unit to apply a pressure against the lower surface area of a synthetic rubber pressure bulb. This pressure, the hydrostatic head of liquid in the tank, is transmitted through a small-bore copper or nylon air-line to the indicator. It is, of course, necessary to know the density of the fluid in order to calibrate the indicator in depth units, and also the tank size and shape if readings are required in volume or mass units. By reducing stiffness in the pressure-bulb as much as possible, errors due to changes in atmospheric pressure or in the temperature of the air in the sealed system, have been reduced to negligible proportions. The bulb is made of variable thickness, and is shaped so that in operation it is similar to a rigid-piston of large area, sealed by a membrane of low-stiffness around its edge. The gauge is suitable for all liquids compatible with the materials of the bulb and its housing. To meet varied requirements a choice of six types of installation is available. The transmitter unit, weighing 12 lb. and with an overall diameter of 8¾ in., can be mounted externally with a short pipeline entering either the side or bottom of the tank to penetrate above sludge level. When mounted internally it is either suspended from a chain in one of three different ways, or alternatively firmly clamped in the base of the tank. Three of the methods of internal installation allow the transmitter to be placed above sludge level. The maximum length of airline should, the company say, only be used if the greater part of it is exposed to atmospheric temperature. The maximum recommended working temperature of the transmitter unit is 65 deg. C. (150 deg. F.). The gauge can be equipped with additional accessories to provide automatic high- or low-level alarm indications or automatic control of a pump to maintain the liquid-level in the tank between predetermined limits. (*Firth Cleveland Instruments Limited, Stornoway House, Cleveland Row, London, S.W.1.*)

Electrical equipment for new steel mills

Associated Electrical Industries Limited, Heavy Plant Division, are to supply practically the whole of the electrical equipment for Colvilles' new cold-reduction plant at Gartcosh, near Ravenscraig, Scotland. The new four-stand tandem cold-strip mill will be driven by two 2,000-h.p. d.c. motors for Stand-1, and six 3,000-h.p. d.c. motors for the remaining three stands; the motors being in the "twin-drive" arrangement with a separate motor driving each roll. The tension reel will be driven by a 1,400 h.p. motor. All motors are to be supplied with power from two motor generator sets, each driven by a 14,000 h.p. synchronous motor. The single-stand temper-mill will be provided with two 550-h.p. motors in "twin-drive" arrangement driving the main stand, with a 1,400-h.p. d.c.

motor for the tension reel, and a 700-h.p. d.c. motor for the pay-off reel. All four motors will be supplied with power from mercury-arc rectifiers in cross connection to give regenerative control. As well as the main units, the equipment to be supplied by the company includes a large quantity of control gear and static equipment of the magnetic amplifier type. The associated process lines will also be equipped with A.E.I. motors and control gear, and the mill cranes powered by A.E.I. steelworks Type MDX motors. Contracts have also been placed with A.E.I. for the supply of four 16/20-MVA, 33/11-kV transformers and the necessary 33-kV and 11-kV switchgear. For Colvilles' new hot mill at Ravenscraig, A.E.I. are to supply a large number of type MDX motors and various Ward-Leonard equipments for operating overhead cranes. (*Associated Electrical Industries Limited, Heavy Plant Division, Rugby.*)

The directors of The Harland Engineering Co. Ltd., Alloa, Scotland, announced recently that the operations of its separate wholly-owned subsidiary company, **Harland Drives Limited,** are being merged in a division of the parent company. The change will be carried through as soon as the necessary administrative re-organisation can be introduced. As a first step to this end, the management of Harland Drives Limited will, with effect from February 1st, 1960, be vested in the board of The Harland Engineering Co. Ltd. In all other respects Harland Drives' clients will be dealing and corresponding with the same personnel on drives matters as they have done in the past. The directors point out that in making this change, their intention is solely that of a higher standard of service to clients, and it is their determination to discharge their responsibilities still better in future, that has been largely instrumental in influencing this development. The Harland sectional electric speed interlocked drive was first installed in 1916 on a paper-making machine, and success in that field is perhaps best illustrated by the fact that in 1953 a survey showed that about two-thirds of the free world's newsprint was produced on paper-making machines driven by Harland drives. Extensions in the application of the Harland drives in its different forms have thus made it essential to fully utilise the resources of The Harland Engineering Co. Ltd.

* * *

The outstanding success of the previous exhibition held by **Henry Wiggin and Co. Ltd.,** in London, has prompted the company to stage a similar exhibition at Park Lane House, 45, Park Lane, W.1, from March 21st-25th, 1960, opening daily from 10 a.m. to 8 p.m.—closing 5 p.m. on Friday, 25th. The aim of this exhibition is to help engineers and designers to make the best of the specialised alloys manufactured by the company. These alloys fall mainly into four groups, viz.:—corrosion-resisting alloys, heat-resisting alloys, electrical resistance alloys and materials with special properties. The display will include a large selection of actual components, sub-assemblies, and finished parts in which Wiggin materials play vital roles. During the exhibition a series of lectures will be given on subjects including "Fabricating the High-Nickel Alloys," and a series on the uses of high-nickel and nickel-base alloys in the nuclear power field, in heat-resisting applications, in the electrical and electronic and the chemical engineering industries. There will be a continuous showing of films on applications and fabrication of Wiggin products.

Lord Chandos, Chairman of Associated Electrical Industries Ltd., arrived back at London Airport early last month, after a tour of India which involved travelling some 20,000 miles in three-and-a-half weeks. During his tour, Lord Chandos, at the invitation of the Indian Government, was able to see some of their great industrial projects under construction. Among these were the heavy electrical plant at Bhopal (which he described at a press conference as one of the most far-sighted and imaginative projects he had seen); the huge steel works plant being built at Durgapur by a consortium of British firms; the Bhakra hydro-electric power dam; and the Indian Government locomotive factory at Chittaranjan. A.E.I. are consultants to the Indian Government on the Bhopal project, and are also part of the British consortium building the Durgapur plant. Lord Chandos had meetings with leading members of the Indian Government including the President, Dr. Rajendra Prasad, and the Prime Minister, Mr. Nehru. Associated Electrical Industries Limited, the largest suppliers of electrical equipment to India, are investigating the possibility of increasing their manufacturing capacity in that country.

* * *

The standard Hodgkinson "Low Ram" stoker is supplied with firebars cast from the best cupola melted, heat-resisting iron; but, however, **James Hodgkinson (Salford) Limited** now announce a development of far-reaching importance. New foundry equipment, embodying a mains frequency electric furnace, now installed, is producing Hicrome heat-resisting steel to BSS.-1648/1950, Grade "C." This material possesses heat and wear-resisting properties far superior to the best cupola-melted irons, with the result that with normal usage an exceedingly long life can be obtained. It has the additional advantage of operation without damage at higher temperatures over those encountered in current practice with ordinary heat-resisting irons and it is, therefore, unnecessary to use steam-cooling jets beneath the grates. A consequent saving in fuel, therefore, by using firebars made from this material, will, in many cases cover the additional cost within the first year of operation.

* * *

Under a contract placed by International Combustion Limited, **Hayward Tyler & Co. Ltd.** (a member of Stone-Platt Industries) is to supply the heat exchanger circulating pumps for the Trawsfynydd nuclear power station. The contract, valued at about £100,000, is for l.p. and h.p. glandless pump and motor units operating at 350 lb./sq. in.

Babcock & Wilcox Limited recently announced the following changes in staff appointments: **Mr. A. S. Peacock,** A.M.I.Mech.E., M.Inst.F., has been appointed purchasing controller, in which capacity he now has responsibility for all matters of company buying policy. He will operate from the London headquarters of the company at Babcock House, 209, Euston Road, London, N.W.1. **Mr. J. S. Greenhalgh** has relinquished his appointment as purchasing controller, and is now manager, Construction Equipment Division, with responsibility for control and co-ordination in the manufacture and marketing of new Babcock products for the building and contracting industries, e.g. **Babcock-Richier** vibratory road-rollers and concrete-mixers, **Babcock-Weitz** tower cranes and **Babcock-Marion** earth-moving equipment, all of which are to be produced at the Dalmuir Works of the company in Scotland. The headquarters of the new Construction Equipment Division is at Lynton House, 7-12, Tavistock Square, London, W.C.1.

* * *

It is with regret that we record the death, on January 22nd, of **Mr. Harold Gwynne Allen,** M.A. (Cantab.), who until his retirement on June 30th, 1959, was a deputy-chairman of W. H. Allen Sons & Co. Ltd., Bedford. Born in 1874, Mr. Allen had devoted a life-long service to the company, including a period of over 50 years as a director and, from 1928 to his retirement, as a deputy-chairman. The father of Mr. W. Kenneth G. Allen, chairman of the company, and of Mr. H. Norman G. Allen, managing director, Mr. Harold Allen was the third son of Mr. William Henry Allen, who founded the business in 1880.

* * *

Mr. L. G. Avis, A.M.I.Mech.E., A.M.Inst.F., has been appointed manager of the London and Southern Region of **John Thompson Water Tube Boilers Co. Ltd.** He joined the John Thompson organisation in 1951 and, after spending three years in the service of a number of the Group's companies, he joined the London office staff in 1954. The John Thompson Conveyor Company have appointed **Mr. P. D. Hunter** as their London and Southern Area sales engineer and as such, he will be responsible for all sales and services in Central London and the Home Counties. Mr. Hunter thus assumes the duties which were previously the responsibility of **Mr. J. M. Tudor,** who will now be at the company's head office in Ettingshall, Wolverhampton. Both Mr. Avis and Mr. Hunter will have their headquarters at John Thompson Limited offices, Imperial House, Kingsway, London, W.C.2.

OVERSEAS Steam Engineering Practice

Abridgments of recent articles in the colonial and foreign technical press, concerning design and progress in the technique of steam generation and power plant equipment

A 100-MW industrial power station

The new George F. Weaton power station of the St. Joseph Lead Company, at Monaca, Pennsylvania, comprises two 56-MW turbo-alternator units supplied with steam from two boilers, each with a capacity of 375,000 lb./hr., at 1,850 lb./sq. in. and 1,000 deg. F., and designed to reheat 278,000 lb./hr. at 424 lb./sq. in. and 1,000 deg. F. Each of the steam generator systems was made independent of the other by having boilers and auxiliaries arranged on a unit basis where practical. Heat cycle efficiency was increased and cold start-up made possible by utilising turbine-driven boiler feedpumps for each boiler. This feature assured greater reliability. Each boiler feedpump is designed to supply the full-capacity of the units. The turbine on the main boiler feedpump is supplied with steam from the cold reheat line and is intended for operation from approximately 60 per cent. load to full load. For operations at less than 60 per cent. load, an auxiliary supply of steam is available from pressure-reducing stations at 625 lb./sq. in. The auxiliary boiler feedpump turbine is normally supplied with steam at 625-lb./sq. in., but is capable of operating from approximately 250-lb./sq. in. pressure up to the maximum of 625-lb./sq. in. A 1,125-kW diesel-electric power unit is provided to supply the start-up power. Start-up procedure is to place in operation a circulating-water pump, the boiler fans, and limited auxiliary equipment until power is being generated by the main unit. While the boiler is being brought up to pressure, the feedwater is supplied by a small electrically-driven pump to about 250 lb./sq. in. At this point, the auxiliary boiler feedpump takes over and from then on will supply the boiler feedwater. After the unit is synchronised, the generation of power may be started and the diesel unit cut off. The auxiliary boiler feedpump is always kept on a slow-speed idle and arranged for automatically picking up the load upon failure of the main boiler feedpump for any reason. The system will remain in operation in this way until it is manually switched over to the standard main boiler feedpump. The main boiler feedpump has an extraction point for supplying steam to heater No. 4, and exhaust from the turbine is taken to the deaerator. The auxiliary boiler feedpump exhausts either into the main unit condenser or, under emergency conditions, to atmosphere. As in most modern steam power plants, extensive use of automatic controls is made. Primary regulation of steam temperature is accomplished by the tilting pulverised-coal burners. The boiler firing rate is set by control of the coal-feeder regulator, exhaust-damper regulator, forced-draught-fan-vane regulator, and induced-draught-fan-damper regulator. Four variable measurements are used for the controls: main-steam-header pressure, total steam flow, total combustion-air flow, and furnace pressure. Mechanical-draught equipment is interlocked so that the forced-draught fan will shut down automatically if the induced-draught-fan should fail or shut-off. Cooling-water is pumped through a 66-in. dia. pipe-line from the Ohio River, and circulates through the condensers, and then returns to the river through a 42-in. dia. pipe. The butterfly-valve which controls the rate of flow through the circulating-water system is operated by a 125-volt d.c. motor. The valve varies the pressure drop or head in the outfall piping to compensate for variations in flow rate. The control arrangement prevents the valve from being opened from the control room unless at least one circulating-water pump is in operation and its corresponding discharge valve open. High-efficiency air-pollution control equipment has also been installed in the plant. A combination mechanical dust-collector and electrostatic precipitator are provided for each unit to remove fly-ash before the combustion gases are discharged to atmosphere. The dust collector-precipitator unit is installed in the boiler exhaust-gas system between the air-preheater and the induced-draught fan inlet. This arrangement greatly reduces fan wear from the abrasive fly-ash. (*Power Engineering*, Vol. 63, No. 12, pp. 73-75.)

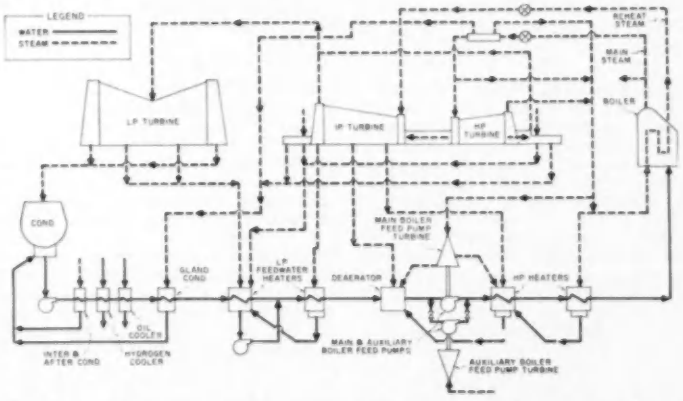


Fig. 1. Flow diagram of the George F. Weaton power station. The main boiler-feed pump has an extraction point for supplying steam to the No. 4 feedwater heater.

On-load washing of air-preheaters

Following initial experiments, the air-preheaters fitted to the boilers at Kyger Creek and Clifty Creek power stations of the Ohio Valley Electric Company have been provided with means for on-load washing. The

necessary equipment was developed in association with the air-preheater manufacture, and will involve very little first cost, when applied to a new plant. Air and gas outlet dampers must be installed in addition to the washing equipment itself. Provision must also be made for drainage of the wash water-deposit slurry from the ductwork below either the air or the gas side. On-load air-preheater washing is based on two principles: (1) solubility in water of certain components in the deposited ash, and (2) removal by water-jets of ash components which are not soluble. Cleaning equipment initially provided consists of a stationary washing device and a movable lance, both located above the air inlet side of the heater. The stationary device, designed primarily to pre-soak the ash, is supplied from the treated-water system. The movable multiple-nozzle lance, designed to remove the pre-soaked deposit, is supplied from high-pressure service water. Water-ash slurry is drained through a 6 in. pipeline from below the air side of the preheater, and passed to the fly-ash removal system at Kyger Creek and to the pulveriser pyrites disposal tanks at Clifty Creek. Before washing of a preheater commences, the boiler load is reduced to approximately 75 per cent of normal full load, and the gas outlet damper is closed on the heater to be washed. After the air temperature has dropped to 300 deg. F., the air outlet damper is closed. By cooling heating-surface elements, evaporation of moisture and carryover to burners through damper leakage are minimised. Next, the preheater rotor speed is reduced to 1/12 r.p.m., and water is admitted to the stationary washing device for pre-soaking. Immediately following these operations, the movable lance is placed at its innermost location, and the high-pressure water jet is turned on. The lance is moved out 1 in. every 12 minutes until it has crossed the air side of the heater. About ten hours are required to cover all of the heater surface during this first pass. Since the deposit is normally most severe on the outer periphery of the heating surface, the lance is again moved in about 20 in. from its outermost position and a second run is made over the outer area. Acidity of the drain effluent is checked periodically during washing by pH measurement to gauge the effectiveness of cleaning. Normal cleaning time established under this method is approximately 16 hours per heater. Experiments are being conducted with the addition of wetting agents, and revised operating procedures and techniques are being studied. The results of this work are expected to eventually shorten the washing time to perhaps one-half of the present time. In addition to the estimated saving in replacement power costs, on-load air preheater washing is expected to contribute significantly to greater plant efficiency and, hence, less fuel consumption. Experiments are now under way to evaluate the effects of operating the units with lower flue-gas exit temperatures. It would appear that it may be possible to reduce exit gas temperature by 15 deg. F. Such a reduction would reflect a gain of approximately 0.3 per cent in boiler efficiency; this, in turn, would result in fuel saving for the two plants of approximately 20,000 tons per year. (*Electric Light and Power*, July 15th, 1959.)

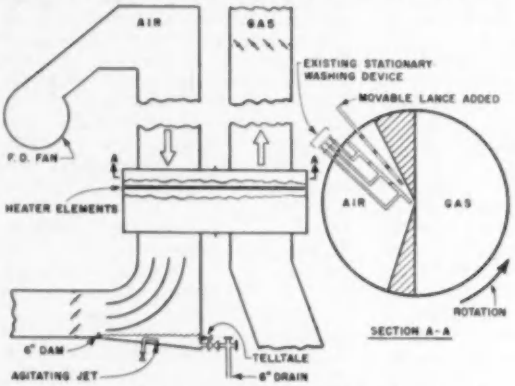


Fig. 2. Schematic arrangement showing on-load pre-heater washing and drainage facilities. The moving lance has four tees and short pipe sections to direct water downward through the cold-end elements and air-ducts.

William Boby & Co. Ltd., water-treatment engineers, Rickmansworth, Herts., are entering the Australasian market, and are establishing local manufacture of plant in conjunction with Australian firms—virtually introducing a new industry to that part of the world. Acting initially through **Elder Smith & Co. Ltd.,** Adelaide, Boby's water-treatment plant and electrodialysis stacks will eventually be completely made in new factory-design units, in each of the Australian States. A senior Boby technical representative, **Mr. P. E. Matthews** is now in Adelaide. He will be in Australia for at least six months. This move by Boby's follows the world tour by **Mr. Michael Boby** (managing director), during which he spoke on the Australian radio network, and discussed local water problems with leading engineers, research staffs and industrialists. Australia is developing fast industrially, and good water is required for process purposes, etc. It is quite obvious that if good water could be produced from local " bad " supplies—by electrodialysis or demineralisation plants—many problems could be solved.

M. de Malmain, President of Ateliers et Chantiers de Bretagne of Paris and Nantes, and **Mr. Robert C. Rodger,** managing director, Cockburns Limited, of Cardonald and Rotterdam, announce a further step in the long association of their companies which commenced in 1910. Under the new agreement, Messrs. Bretagne will manufacture Cockburns' products for marine, industrial and atomic applications, in France. They will also act as Cockburns' selling agents for France and Algeria. Additionally, a reciprocal arrangement has been completed whereby Cockburns Limited, manufacture certain of Bretagne's units, including special compressors and evaporators, in Britain. Cockburns will also act as Bretagne's selling agents for these units in Canada, Australia, South Africa and certain other parts of the British Commonwealth. It is also announced that a tri-party agreement is under final discussion between these two companies and **Messrs. Black, Sivalls & Bryson,** of Kansas City, which covers the European manufacturing and marketing of the well-known range of B.S. & B. pressure-regulating equipment.

Nash & Thompson Limited have acquired a second factory at Hook Rise, Tolworth, within 200 yd. of their present Research and Production Unit in Oakcroft Road, Chessington, Surrey. This new factory has increased the available space by 35,000 sq. ft., and the transfer of administrative departments, research and development and some production departments has now been completed. The purchase of this property was made necessary by the continued expansion of production and development during the last few years. More than 30 new instruments have been added to the range of standard instruments during the last two years. These instruments include many of the well-known Nashton range of miniaturised electronic test equipment, several metallurgical instruments, equipment for survey work, plant and components for process control. Other activities range from the manufacture of scintillator chemicals for the detection of radioactivity, to the design and manufacture of analogue simulators for the C.E.G.B., including a six-bay equipment for the simulation of the future cross-channel power link system.

Latest Power Plant Patents

These extracts from British Patent Specifications are reproduced by permission of The Controller of H.M. Stationery Office. (Complete British Specifications can be obtained from the Patent Office, 26, Southampton Buildings, London, W.C.2. Price 3s. 6d. each, both inland and abroad.)

Steam generator

This invention concerns a method of operating a heat-exchanger for heating the working medium in a steam generator having radiation-heated, and contact-heated sections heated by means of hot gases. The heat-exchanger, according to the invention as applied to a steam generator, has a section heated by radiation, and a section heated by contact with hot gases; the flow of the working medium is divided and arranged to pass in parallel through the two

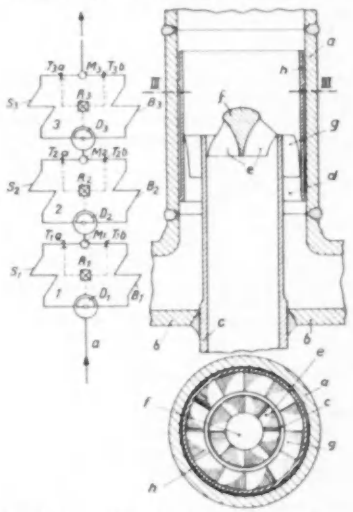


Fig. 1 (top, left). Fig. 2 (top, right). Fig. 3 (right). British Patent No. 819,106.

sections and then reunite. The flow is divided between the two sections in order to maintain substantially equal the temperatures of the working medium emerging from the two sections. Fig. 1 shows a diagram of three heat-exchanger stages forming part of a steam generator. The three superheater stages (1, 2 and 3) are shown. Each superheater stage is divided into a radiation-heated section (S_1, S_2 and S_3) respectively, and a contact-heated section (B_1, B_2 and B_3) respectively which are connected in parallel, the three stages being connected in series. The total amount of steam produced in the steam generator flows to the first superheater stage (1) from a header through a rotary valve (D_1) which divides the total amount of steam between the radiation-heated section (S_1) and the contact heated section (B_1). Temperature measuring means (T_{1a} and T_{1b}) are provided at the outlets of the sections (S_1 and B_1) respectively, both temperature measuring means transmitting the measured values to a regulator (R_1) of known type. In this regulator, the two temperatures are compared with one another, and if there is a difference in temperature, the rotary valve (D_1) is so adjusted that each of the two sections (S_1, B_1) receives a corresponding proportion of the flow of the working medium. In accordance with the divided flow, the outlet temperatures of the two sections (S_1 and B_1) are acted upon until the two temperatures have assumed the same value. Downstream of the temperature measuring means, the divided flows emerging from the sections (S_1 and B_1) are re-mixed with one another in a mixer (M_1) and passed to the next superheater-stage (2), where the process is repeated. In the mixer outlined in Figs. 2 and 3, the steam fractions from the radiation-heated section (S_1) and from the contact-heated section (B_1) are mixed by means of whirling, in order to avoid the formation of unmixed streams. Also, if there is any difference between the pressures of the flows from the two parallel heat-exchanger sections, which will alter on variation of the flow, it will be converted in the mixer into velocity which will also promote good mixing. The outlet pipe (b) from the radiation-heated section (S_1) is connected directly by means of a T-junction to a common outlet pipe (a), while the outlet pipe (c) from the contact-heated section (B_1) passes through the wall of the outlet pipe (b) into the interior of the common outlet pipe (a) within which it is supported concentrically, leaving an annular gap (d) between it and the common outlet pipe (a). At the end of the outlet pipe (c) there are provided eddy plates or guide blades (e) and a centrally-placed guide body (f) which guides fluid flowing from the pipe (c) radially outward. Similarly, in the annular gap (d) at the end of the outlet pipe (c), there are eddy plates (g), the direction of swirl of which is opposite to that of the guide blades (e). To protect the walls of the common outlet tube (a) at the point where the two streams of fluid from the pipes (b and c) are brought together, there is an internal sleeve (h). The invention is of very wide application; it can be applied to any heat-exchanger stage of a steam generator; for example, an economiser, an evaporator, a superheater or intermediate superheater, or only a part of one of these heat-exchangers. *British Patent No. 819,106 issued to Sulzer Freres S.A. Complete specification published August 26th, 1959.*

Pressure exchanger

This invention relates to power plant including a pressure exchanger. Fig. 4 is a diagrammatic illustration of such a power plant. Referring to Fig. 4, numeral (1) denotes a ring of axially extending open-ended cells, drawn as a circumferential development. The cell ring is movable in the direction of arrow (X) past stationary end-plates (13, 14). Low-pressure scavenging stage inlet and outlet duct, (2 and 3) respectively, communicate with cells (1) through apertures in the end-plates. Numerals (4 and 5) represent the heat input stage inlet and outlet ducts respec-

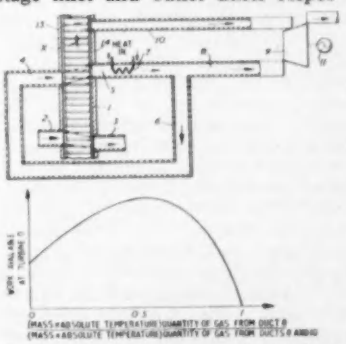


Fig. 4 (top). Fig. 5 (bottom). British Patent No. 819,304.

tively, which also communicate with the cells (1) through apertures in the end-plates. The ducts (4 and 5) are connected externally of the cell ring by a duct (6). In the duct (5) there is a heating-coil (7). Thus, the

ducts (4, 5 and 6) and the cells momentarily in communication with the ducts (4 and 5) constitute a heat input stage. The outlet duct (5) also communicates with a heat input stage extraction duct (8) which conveys hot gas from the heat input stage to a turbine (9), the shaft of which is connected to an electrical generating machine (11). Circumferentially-spaced from the duct (5), in the direction of rotation of the cell ring, there is an additional extraction duct (10), which also conveys hot gas from the cell ring to the turbine (9). The duct (10) communicates with a lower pressure stage of the turbine than does the duct (8), as the pressure of gas in the duct (10) is lower than the pressure of gas in the duct (8). The flow characteristics of the turbine are such that the flow of gas through the ducts (8 and 10) is in the correct proportion to produce as much work as possible. This will be explained in more detail with reference to Fig. 5. The turbine may have adjustable inlet-nozzles of the partial admission type at the stages with which the ducts (8 and 10) communicated. In operation, gas (e.g., fresh air) is drawn into the cells through duct (2) is compressed and is carried to the heat input stage in the vicinity of ducts (4 and 5). Gas in the cells is withdrawn through duct (5) and is reintroduced through duct (4); but part of the gas circulated in this way is extracted through duct (8) to drive the turbine. Gas in the cells, after leaving the vicinity of the heat input stage, is expanded, and part of the gas is extracted through duct (10) to drive the turbine (9). Gas remaining in the cells then leaves through duct (3), and fresh gas enters through duct (2). The cycle of operation is then repeated. The compression and expansion is effected by shock and expansion waves respectively set up by the opening and closing of cells to the ducts (2, 3, 4, 5 and 10). In Fig. 4 shock waves are indicated by full lines, and expansion waves by broken lines. The ducts (2 and 3) and the ducts (4 and 5) have been shown positioned with their ports circumferentially close together, so that a shock wave combines with an expansion wave. Fig. 5 shows a typical graph of total work available from gas in the ducts (8 and 10) plotted against the ratio of the quantity of the gas in duct (8) to the quantity of the gas in both ducts (8 and 10). It will be seen that maximum work will be available when approximately 0.6 of the total quantity (mass multiples by absolute temperature) is from the gas extracted through the heat input stage duct (8) and approximately 0.4 of the total quantity (mass multiplied by absolute temperature) is from the gas extracted through the additional extraction duct (10). As more or less gas is taken from duct (8), so the work available will decrease. It is, therefore, preferable to operate the pressure-exchanger substantially at the suggested optimum value. For different efficiencies of compression and expansion, and for different pressure-levels, i.e., for different designs of pressure-exchangers, the graph will vary in shape. The optimum value may occur further to the right or left as seen in Fig. 5. By providing adjustable inlet nozzles in turbine (9), the pressure-exchanger may be operated at a desired point on the typical curve illustrated in this figure. *British Patent No.* 819,304 *issued to D. B. Spalding. Complete specification published September 2nd,* 1959.

Cleaning heating surfaces in economisers

This invention refers to means for cleaning heating-surfaces in economisers and similar equipment with the aid of particles falling against the heating surfaces. The particles consist, for instance, of steel shot conveyed to the upper part of the equipment where a supply container provided with a feeding device is arranged. The particles are then caused to fall through the installation *via* a spreading contrivance whereupon they are reconveyed to the upper part. The drawings show in Figs. 6 and 7 an installation comprising an economiser, the heating surfaces of which consist of tube bundles (1), for example, arranged in a shaft (2) above one another. Extending into the upper portion of the shaft (2) are one or more substantially horizontal feed pipes (3) from one side of the shaft. These pipes have outlet openings above spreading contrivances consisting substantially of deflecting members (4) against which the cleaning solids fall down. The outer ends of the pipes extend from a feed-trough (5) which receives cleaning solids, such as steel shot (6), Fig. 8, from a supply container (7), and which feeds these solids continuously or intermittently into the pipes (3). The feed pipes (3) are carried, as is the feeding trough, by hangers, links or springs (8), and are connected to vibrating equipment (9). The latter equipment causes vibrations or shaking, so that the cleaning solids will, by reason of these vibrations, be conveyed from the trough (5) to the outlet openings. The shafts (2) merge at the bottom into a pair of pockets (10) in which the steel shot is collected, on having fallen down through the shaft. The latter is provided at the bottom with a flue gas outlet (11) to deflect the flue gases arriving at the top through an inlet (12) to chimney ducting. The pockets (10) are connected at the bottom to a discharging device

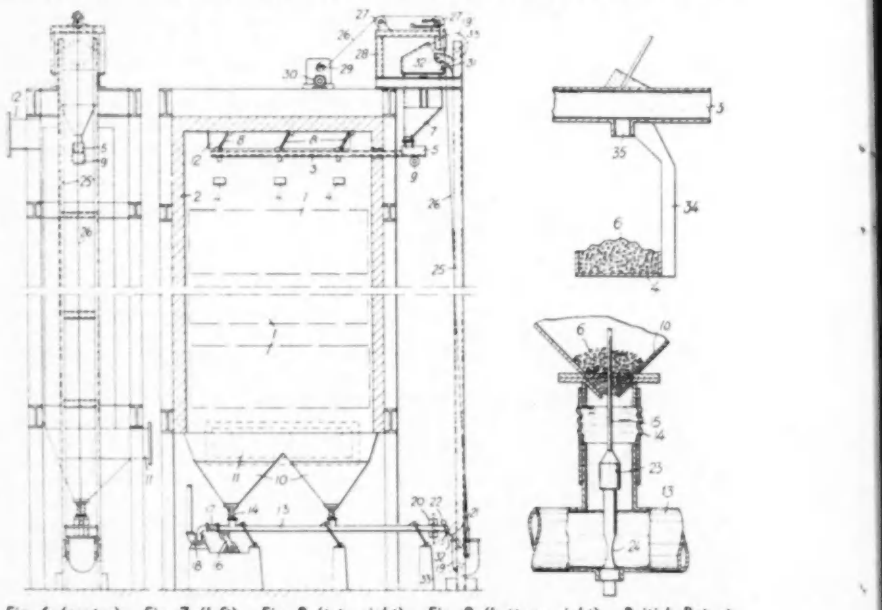


Fig. 6 (centre). Fig. 7 (left). Fig. 8 (top, right). Fig. 9 (bottom, right). British Patent No. 826,844.

for the cleaning solids collected in the pockets, this device being also constructed for the separation of impurities through vibration. This device comprises, first, a substantially horizontal tubular vibration channel (13), to which the cleaning solids are conveyed from each pocket through a flexible pipe connection (14), and second, a feed rod (15), which is secured to the bottom of the vibrating channel and extends upwardly into the bottom opening of the pocket, as shown in Fig. 9. The shaking channel is connected, for instance, to an electric vibrator (16). The shaking channel consists of one or more pipes, one end of which communicates through a hose connection (17) with the suction side of a fan (18), and the other end of which is uncovered and opens above a container (19) when the latter takes its lowermost position, viz.:—the loading position. In the pipe (13), near the end located at the container (19), is arranged an electric heating element (20) or some other source of heat, for the purpose of keeping the temperature of the cleaning solids sufficiently high to prevent condensation. To the same end, flue gases may be connected into the pipe (13), which may be closed by means of a cut-off device comprising a damper (21), which in its open-position bears on the edge of the container (19) and is maintained in closed position by a counterweight (22). *British Patent No.* 826,844 *issued to K. E. Patenter AB. Complete specification published January 27th,* 1960.

Many years ago, both the **British Thomson-Houston Company** and **Metropolitan-Vickers Electrical Company,** set up specialist departments to carry out what is known as application engineering, including the co-ordinated selection of electrical machines and design of control schemes, with the result that a long record of technical achievement stands to their credit. When A.E.I. Heavy Plant Division came into being on 1st July 1958, two such departments were formed in the Division—one at Rugby and one at Manchester, from similar departments already existing in BTH and M-V. These two departments have both continued to deal with the application engineering of complete electric drives for rolling-mills, mine-winders, and associated installations. Effective co-operation between these two departments within the Division has now made it possible to unite them in a single new Plant Applications Engineering Department which, having the combined resources and experience of both, will give yet better service to the Division's many customers throughout the world.

* * *

John Thompson Limited, Wolverhampton, recently issued an illustrated brochure giving a brief indication of the resources available for John Thompson's service to industry. For more than 125 years the company have performed specialised services for the basic industries of Great Britain and countries overseas—in the manufacture of steam boilers and ancillary equipment for industrial and power generation purposes, and in the production of pressure vessels and heavy and light pressed metal work. Today, under the fourth generation of management by the same family, the range of the Group's activities have been extended to the manufacture of nuclear power plant equipment.

* * *

James Gordon & Co. Ltd., Dalston Gardens, Stanmore, Middlesex, are holding a private exhibition at The Lion Hotel, Warrington, Lancs., of representative equipment which they manufacture. The exhibition will be held on April 5th, 6th and 7th, from 5-30 p.m. to 9-30 p.m. each day. The exhibits to be featured will comprise instrumentation and automatic controls for boiler plant, furnaces, heating installations, steam supplies, etc. Members of the company's technical staff will be present to discuss any instrumentation problems which visitors may have.

The starting-up recently of the fast breeder reactor at Dounreay, in the north of Scotland, focuses attention on the activities of **The Morgan Crucible Co. Ltd.,** Battersea. This company has been permitted to reveal that. for the first time, special borated graphite blocks were used by the United Kingdom Atomic Energy Authority in the assembly of the shield which surrounds the reactor vessel at this experimental station. The blocks were made and machined by The Morgan Crucible Co. Ltd. at their works at Norton, near Worcester. This factory is not engaged in the production of nuclear pure material, and was, therefore, chosen as one suitable for handling large quantities of boron compounds. The purpose of the borated graphite is to slow down fast neutrons and then absorb them in the shortest possible distance, thus providing a safety screen. Most of the borated graphite contained 0.3 per cent. boron, but some contained 5 per cent.—in both cases very uniformly distributed throughout the graphite. The blocks themselves were machined to 500 different patterns.

* * *

Daniel Adamson & Co. Ltd., Dukinfield, recently issued a new 52-page brochure describing the various designs of shell-type boilers manufactured by the company. This well-produced brochure is, from the point of view of convenience, arranged in sections, with brief descriptions and illustrations for each type of unit. The many and varied illustrations of actual boiler plants for which the company have been responsible, give an indication of the facilities which they have for the manufacture of boiler plant for many different industrial requirements. For more than 100 years, Daniel Adamson & Co. Ltd. have been making boilers of all types, for installation and efficient operation all over the world, and they include—Economic type units of either the double-pass or treble-pass type with capacities from 2,000-19,000 lb. hr.; Super Lancashire type boilers for capacities upwards of 10,000 lb. hr.; Lancashire boilers 2,810/22,320 lb. hr.; Vertical boilers 560/3,120 lb. hr.; and Package boilers of capacities ranging from 2,000-10,000 lb. hr. The Daniel Adamson Package boiler is a self-contained fully-automatic compact unit designed to meet modern demands for steam generating and high-pressure hot water systems.

Mr. F. W. Tomlinson, managing director, Pyrotenax Limited, **Mr. J. M. Willey,** director and general manager, Murex Welding Processes Limited, and **Mr. P. S. Bryant** of Murex Limited, have been appointed to the board of Murex Limited, Rainham. Mr. Tomlinson has also been appointed to the board of Murex Welding Processes Limited, Waltham Cross.

* * *

Fibreglass Limited has announced that **Mr. P. J. M. Swiney** has relinquished the appointment of market research officer to take up special duties as overseas sales promotion officer. **Mr. Stanley Gaskell** has been appointed market research manager. **Mr. C. M. Johnson** has taken over as area sales manager, north-eastern (England) area, and has been succeeded as Scottish area sales manager by **Mr. R. Bowman.**

* * *

Holloway Brothers (London) Ltd. has been awarded a contract valued at £320,000 by the Central Electricity Generating Board for the main foundations for extensions to the Bankside "B" power station at Southwark, London. These extensions will include new switch, boiler and turbine houses, work on which will commence in early 1961. The consulting engineers are **Messrs. Mott, Hay and Anderson.**

* * *

Mr. H. Cartwright, hitherto deputy director of Industrial Power in the United Kingdom Atomic Energy Authority's Development and Engineering Group at Risley, has been appointed director of Industrial Power.

* * *

Bryce Electric Construction Co. Ltd. announces that **Mr. D. D. Hogg,** A.M.I.E.E., has been appointed contracts manager, and that **Mr. J. O. M. Palmer,** A.M.I.E.E., has been appointed chief engineer.

* * *

British Engine, Boiler and Electrical Insurance Co. Ltd. announces that **Mr. R. R. Mason,** general manager, has been appointed a director. He will retire from the position of general manager on April 30th, and will be succeeded by **Mr. K. W. Bradshaw.**

* * *

We have received from **W. C. Holmes & Co. Ltd.,** P.O. Box No. B.7, Turnbridge, Huddersfield, a new publication (No. 80) which describes the Holmes-Schneible multi-wash system for the collection and cleaning of dust-laden gases and fumes in industrial plants.

NOTES *Personal* AND *Industrial*

Mr. John F. Perry, who until recently was managing-director of Metropolitan-Vickers Electrical Export Co. Ltd., and a director of A.E.I. (Overseas) Limited, has been appointed chairman of **Fluidrive Engineering Co. Ltd.,** in succession to **Mr. Harold Sinclair.** Mr. Sinclair has also retired from the board, as he is desirous of concerning himself more fully with the work of associated companies in the field of patents and licensing thereunder, principally on the Continent of Europe and North America; this will ensure Mr. Sinclair's continued association with the company.

* * *

Cockburns Limited, Cardonald, Glasgow, announce that the following managerial appointments have been made. **Mr. L. W. Noble,** formerly manager of North Shields branch works, becomes manager, London Office, and **Mr. W. A. Duckworth** has been appointed manager of a new office which has been opened in Manchester to serve, particularly, the chemical processing industry.

* * *

Due to their increasing expansion and heavy industrial commitments, **Foster, Yates and Thom Limited,** Blackburn, heavy precision engineers and boiler makers, have created the new post of assistant general manager. **Mr. O. D. Gwilliam,** who was previously works manager of W. C. Holmes & Co. Ltd., Huddersfield, has been appointed to this post and will be assistant to **Mr. R. Lucas,** the company's general manager.

* * *

Mr. S. H. Ireland, B.Com., B.Sc., has been appointed assistant managing director of the Consolidated Pneumatic Tool Co. Ltd., Dawes Road, S.W.6.

* * *

The British Iron and Steel Research Association has announced that **Mr. S. S. Carlisle,** A.M.I.E.E., head of the physics department, has been appointed an assistant director.

* * *

Mr. C. Donaldson, who since 1955 has been deputy-superintendent of Stella North power station, in the North Eastern Division of the C.E.G.B., has been appointed station superintendent in succession to **Mr. C. R. Garnett.**

* * *

Mr. Eric A. Robinson, M.C., M.I.Mech.E., chairman and joint managing director of the **Superheater Co. Ltd.,** retired from the position of joint managing director on January 31st last, but remains chairman of the company. **Mr. L. C. Southcott,** B.Sc., A.M.I.Mech.E., joint managing director has been appointed managing director.

* * *

It is with regret that we record the death, on January 25th, of **Mr. E. R. Crammond,** who had, since March, 1937, been deputy-chairman of Hopkinsons Limited, Huddersfield.

Mr. L. C. Richards, until recently chief engineer of the Transformer Division of Associated Electrical Industries Limited, has been appointed chief engineer to **Heavy Electricals Limited,** India. He is seconded to this position from A.E.I. Overseas Limited, to whom he has been transferred. Heavy Electricals Limited is the Indian Government Company building the important heavy electrical plant manufacturing centre at Bhopal. Total investment here by the Indians will amount to more than £80-million, and the centre is due to start production in July next. A.E.I. are consultants to the Indian Government on the project, which is expected eventually to have an annual output worth £37-million.

* * *

Mr. R. N. Millar, M.A., B.Com., M.I.Mech.E., M.I.E.E., a director of The General Electric Co. Ltd., has been appointed managing driector of the company's Engineering Group which has its main works at Erith, Kent, and Witton, Birmingham. Mr. Millar will have overall responsibility for the whole of the company's activities in the heavy electrical, mechanical and nuclear fields.

* * *

Mr. E. P. Collins, advertising manager of The Morgan Crucible Co. Ltd., and its associate companies, has recently been elected hon. secretary of the Incorporated Advertising Managers Association. Mr. Collins has been a member of the society for 13 years, and was recently awarded a Fellowship for his services to advertising and to the Association. He is also a member of the technical committee of the Incorporated Society of British Advertisers as well as being the I.S.B.A.'s representative on the controlled audit sub-committee of the Audit Bureau of Circulations Limited.

* * *

Mr. J. N. M. Legate, B.Sc., A.M.I.E.E., has been appointed manager Control Gear Engineering Department (Manchester), of A.E.I. Motor and Control Gear Division.

* * *

Mr. O. T. Evans, Assoc. M.C.T., A.M.I.Mech.E., M.I.E.E., has been appointed manager, and **Mr. W. Spencer** B.Sc., M.I.E.E., A.M.I.Mech.E., deputy manager of the new Plant Applications Engineering Department of A.E.I. Heavy Plant Division, with headquarters at Rugby.

* * *

The Electricity Council announce that **Mr. F. L. Harris,** M.I.E.E., A.M.I.Mech.E., who was regional safety officer, Yorkshire and North Eastern Region for seven years, has been transferred to the Midlands and East Midlands Regions. **Mr. E. K. Clarke,** A.M.I.E.E., has been appointed regional safety officer, Yorkshire and North Eastern Region, in succession to Mr. F. L. Harris, with effect from 15th February, 1960.

Mr. G. P. Thompson, until recently manager (transformer factory) at Rugby Works, has been appointed manager—(manufacturing) A.E.I. (Rugby) Ltd. He was appointed chief assistant to the superintendent of the transformer factory in 1950, and manager of that factory in October, 1953. As manager—(manufacturing) at Rugby Works, he succeeds **Mr. D. Edmundson** whose appointment as general manager was recently announced. The new manager of the transformer factory is **Mr. R. Thomson,** A.M.I.W.M., who was assistant superintendent (transformer factory) from May, 1956, until October, 1957, when he was appointed superintendent.

* * *

The Bristol branch office of **Brook Motors Limited,** Huddersfield, is now situated in larger and more convenient premises at the Refuge Assurance Building, 18, Baldwin Street, Bristol, 1. The telephone number remains unchanged.

* * *

Powell Duffryn Technical Services Limited has removed from 19, Berkeley Street, London, W.1, to Boundary House, 7/17, Jewry Street, London, E.C.3, (telephone, Royal 0141).

* * *

The name of **W. R. Skinner Limited,** the service subsidiary of the Weir Group in London and south-east England has been changed to **Weir, Drysdale Service (London) Limited.** The address remains the same, viz—Caxton Street North, London, E.16. There has been no alteration whatever in the composition of the company, and its new name emphasises more strongly its membership of the Weir group.

* * *

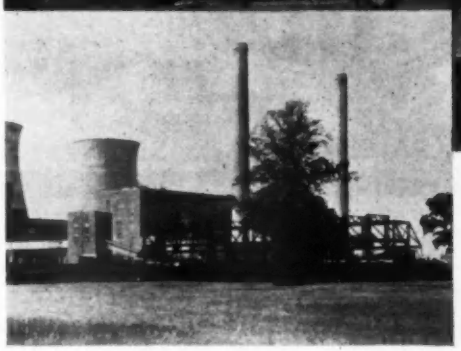
The address of the London branch office of **Beldam Asbestos Co. Ltd.,** and **Auto-Klean Strainers Limited,** is now 109, Fenchurch Street, London, E.C.3. Telephone No. Royal 1148.

* * *

Richardsons, Westgarth and Co. Ltd. has announced the formation of a subsidiary company, **Richardsons, Westgarth Inc.,** with offices in Washington, D.C. The new company will act as selling agent in the United States for products made by the company in this country and will also be able to act as main contractor where plant is made in the U.S.A. to Richardsons, Westgarth designs.

* * *

A leaflet issued recently by **Turner Brothers Asbestos Co. Ltd.,** P.O. Box No. 40, Rochdale, Lancashire, contains information relating to Aluminised Asbestos. This new product is a finishing wrap for lagging installations, which is claimed to provide the advantages of a fire-proof cover cloth, while comparing favourably in appearance with plastic and decorative cleading finishes. It is durable, impermeable to moisture, and achieves increased thermal economy by heat reflection.



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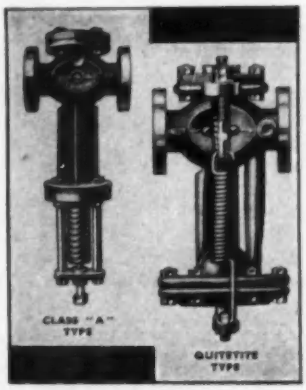

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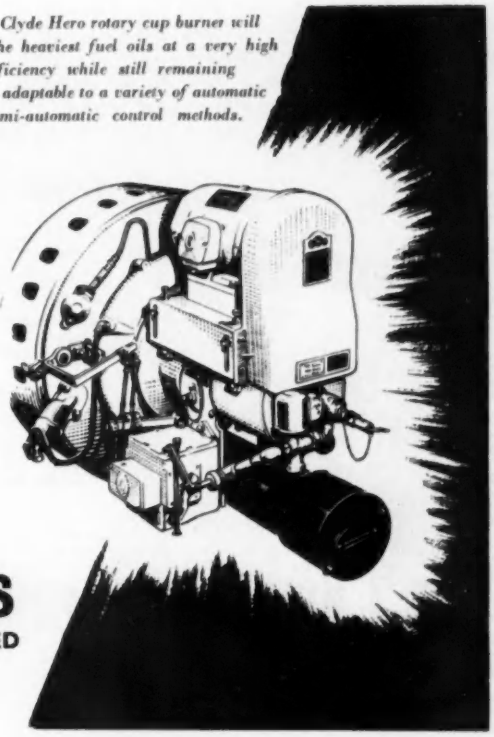

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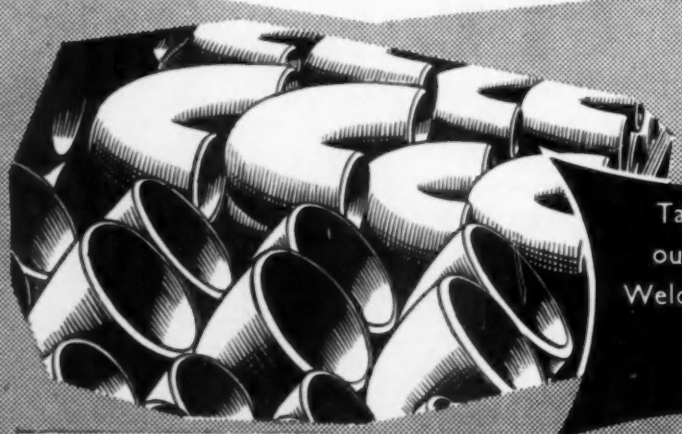

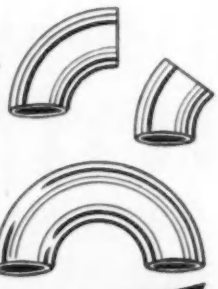

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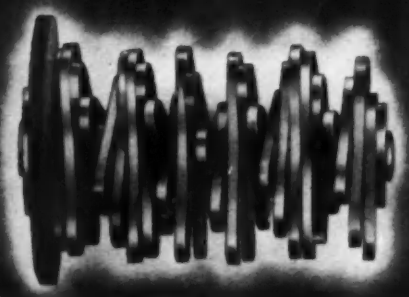

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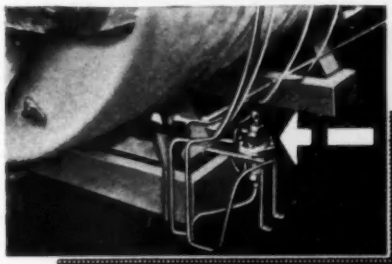

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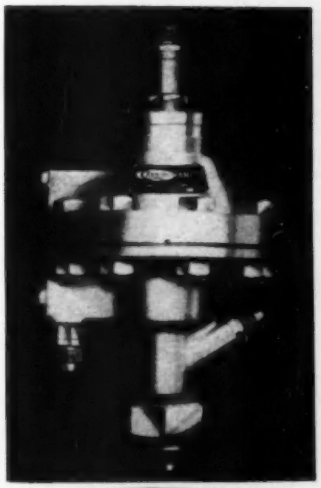

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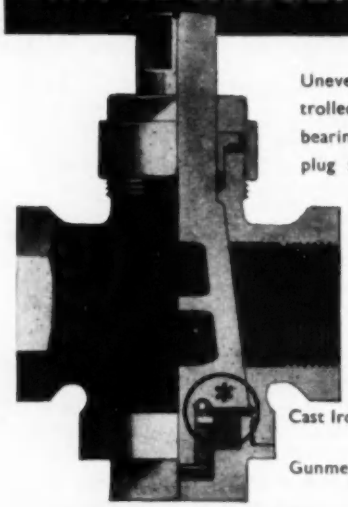

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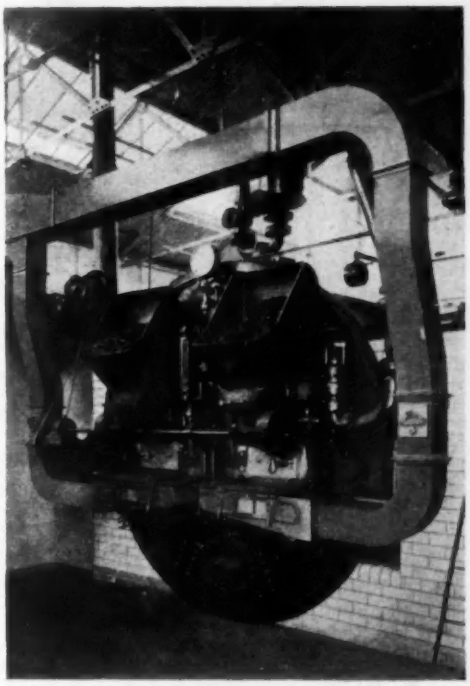

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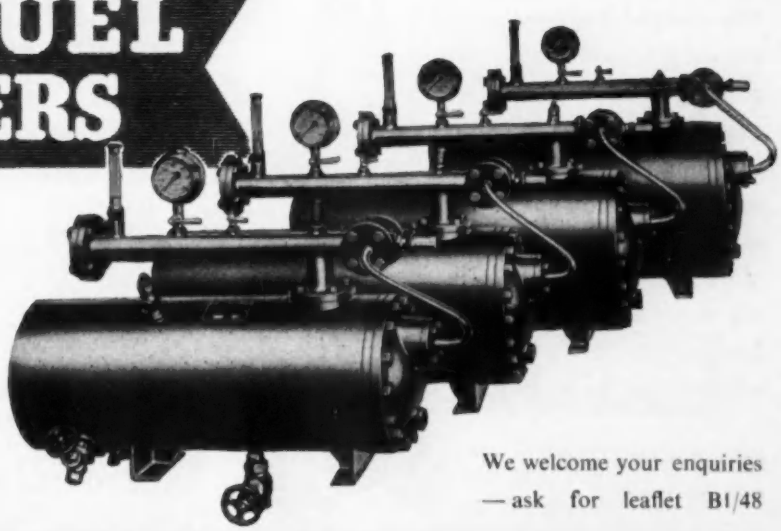

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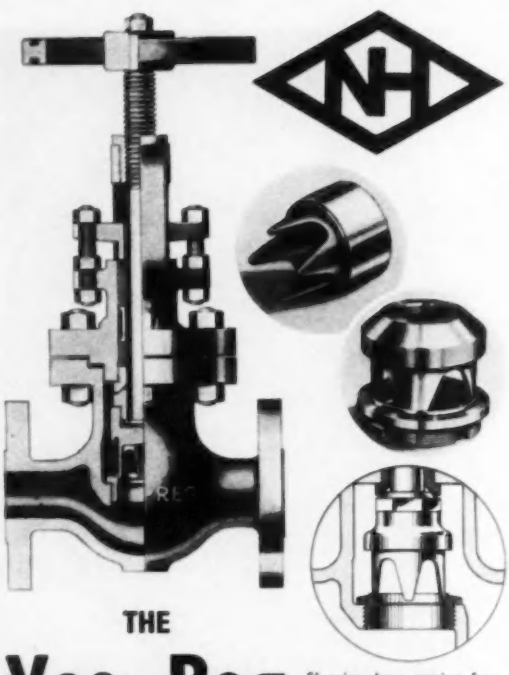

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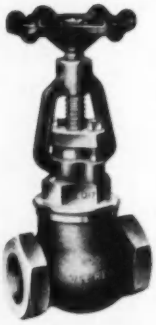

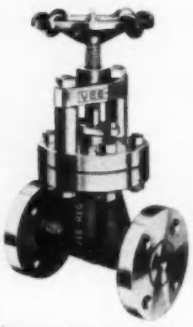

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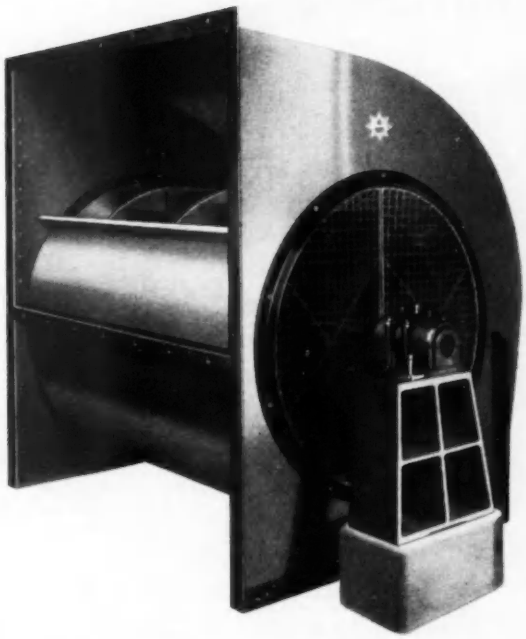

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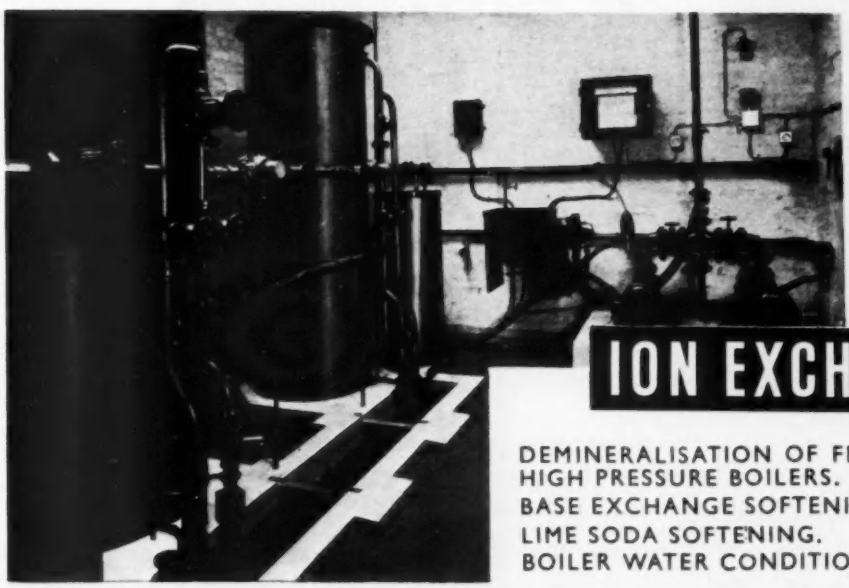

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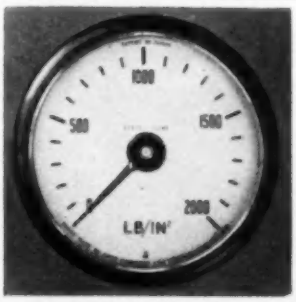

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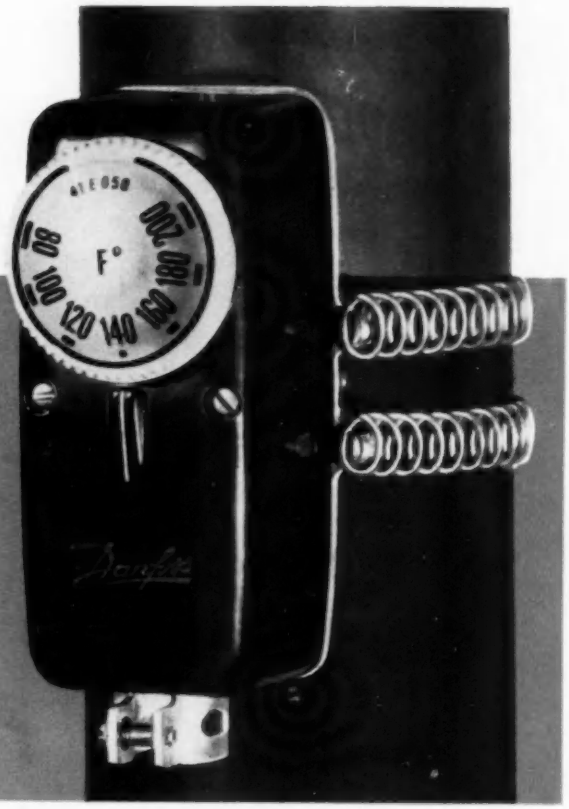

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